

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Applicant:

Boxman et al.

Serial No.: 10/615,141

Filed: July 9, 2003

For: Method and Apparatus for
Producing Nanostructures

Examiner: Kishor Mayekar

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Attorney  
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Commissioner for Patents  
Alexandria, Virginia 22313-1450

AFFIDAVIT OF RAYMOND REUVEN BOXMAN UNDER 37 CFR 1.132

I am presently employed as a Professor of Electrical and Electronics Engineering at Tel-Aviv University, Tel-Aviv, Israel. I received my BS and MS degrees from the Massachusetts Institute of Technology (MIT) in 1969, and my Ph.D. degree from M.I.T. in 1973, all in Electrical Engineering. In 1989 I was named a Fellow of the Institute of Electrical and Electronics Engineers. I was awarded the Boris and Renee Joffe Award, by the International Union for Electrodeposition and Surface Finishing (1984) and the Walter Dyke Award, by the Permanent International Scientific Committee of the International Symposia on Discharges and Electrical Insulation in Vacuum (2000). In 2006, I was named the incumbent of the Kranzberg Chair in Plasma Engineering at Tel-Aviv University. At Tel-Aviv University I have served as Head of the Materials Engineering Program from 1999 to 2006, and Chairman of the Department of Interdisciplinary Studies 1984-1986 and again from 2004 until the present time.

I have authored or co-authored over 160 papers, journal articles, and publications, most of which relate to plasma and electrical discharges, or their use in material processing. Exemplary publications include:

1. A. Moshkovith, V. Perfiliev, D. Gindin, N. Parkansky, R. Boxman, L. Rapoport, "Surface texturing using pulsed air arc treatment" *Wear* (2007) doi:10.1016/j.wear.2006.11.043.
2. N. Parkansky, G. Frenkel, B. Alterkop, R.L. Boxman, S. Goldsmith, Z. Barkay, Yu. Rosenberg and O. Goldstein, "Influence of pulsed arc parameters on powder production in ethanol", *Powder Technology* 162 (2): 121-125 Mar 1, 2006.
3. N. Parkansky, O. Goldstein, B. Alterkop, R.L. Boxman, Z. Barkay, Yu. Rosenberg and G. Frenkel, "Features of micro and nano-particles produced by pulsed arc submerged in ethanol", *Powder Technology* 161 (3): 215-219 Feb. 3, 2006
4. N. Parkansky, B. Alterkop, R.L. Boxman, S. Goldsmith, Z. Barkay, Y. Lereah, "Pulsed discharge production of nano- and micro-particles in ethanol and their characterization" *Powder Technology* Vol. 150 (2005) pp. 36-41.
5. N. Parkansky, R. L. Boxman, B. Alterkop, I. Zontag, Y. Lereah, Z. Barkay, "Single-Pulse Arc Production of Carbon Nanotubes in Ambient Air" *J. Phys. D: Appl. Phys.* Vol. 37, pp 2715-19, 2004.

I have also co-edited a book on Electrical arcs in vacuum: R.L. Boxman, P. Martin, D. Sanders (editors), *Handbook of Vacuum Arc Science and Technology*, Noyes Publications (Park Ridge, NJ) 1995.

My statement follows on page 2; my resume starts on page 7; and a relevant article entitled: "Single-pulse arc production of carbon nanotubes in ambient air" is appended to this affidavit, starting on page 32.

I have examined Patent application no. 10/615,141 of Boxman et al., as well as Patent nos. 6,759,024 and 5,482,601 to Takikawa and Ohshima, respectively.

I would like to clarify that the term “pulse”, as commonly used in the art with respect to conventional DC or AC power supplies, refers to generally short pulses, which are usually produced by special pulse circuits. These pulses contrast sharply with the application of DC or AC electrical excitation for longer periods, e.g. a few seconds, which is usually accomplished by switching on, and then off, a suitable DC or AC power supply, respectively.

#### Short Pulses

Our invention is distinguished from the prior art of both Ohshima and Takikawa in that we teach the use of short pulses ( $<1$  ms), while Ohshima teaches the use only of DC excitation, and Takikawa primarily teaches the use of DC and AC excitation, but mentions also “pulses” of up to 3 s duration. I contend that such long “pulses” are fundamentally different from the short pulses in the instant invention, both because of the technology involved in producing them, and the effect which they achieve.

Relatively long “pulses”, i.e. of a few seconds duration, are typically produced by merely manually switching on and then off a conventional DC or AC power supply. In contrast, short pulses, i.e. pulses of less than 1 ms, and especially short pulses in the preferred duration range of 0.2-20  $\mu$ s, are more economically produced by special pulse circuits, in which energy is first stored in a capacitor or inductor, and then discharged into the plasma load at some predetermined time.

Secondly, the use of short pulses taught in the instant invention, and especially pulses with durations in the preferred range of 0.2-20  $\mu$ s, was found by the inventors to be particularly advantageous in the production of carbon nanotubes (CNTs). The

motivation for trying this range of pulse durations stems from the inventors' insightful analysis of the results of one of Takikawa's scientific publications, as indicated in the specification of the instant invention: "Takikawa, et al. examined the cathode spot track left on a graphite cathode by a 50 Amp, 1.5 second duration arc, driven in the retrograde direction by a 4 mT magnetic field in a 0.5 Pa He gas background. SEM examination of the arc track revealed the presence of numerous multi-walled CNTs at the last location of the cathode spot, but nowhere else. This suggests that the cathode spot sequentially produced CNTs, and then destroyed them, as the cathode spot moved along the surface at approximately 3 millimeters per second, leaving undestroyed CNTs only at the last cathode spot location. See H. Takikawa, Y. Tao, R. Miyano, T. Sakakibara, X. Zhao, and Y. Ando, Jpn. J. Appl. Phys. 40, 2001, 3414-8."

The inventors' analysis of this result suggested that if the arc were excited with a short pulse, perhaps CNTs would be formed, but there would be insufficient time for the cathode spot of the arc to subsequently destroy the formed CNTs. Furthermore, assuming a cathode spot diameter of  $d=3\text{ }\mu\text{m}$ , and using the cited cathode spot velocity of  $v=3\text{ mm/s}$ , the preferred pulse duration  $T$  should be shorter than the time required for the spot to move one diameter, i.e.  $T < d/v = 1\text{ ms}$ . It should be pointed out that cathode spots "move" by being spontaneously extinguished after a random period of time, whose average value may be termed the cathode spot lifetime  $T_{cs}$ . Re-ignition of the cathode spots occurs at an adjacent location, thus giving the appearance of movement. A preferred pulse time would be on the order of magnitude of the spot lifetime, which is typically in the ns- $\mu\text{s}$  range.

This reasoning was verified by experimental work carried out in the inventors' laboratory, reported both in the instant specification and in subsequent publications. In one such work, Y. Zontag showed in his MS thesis "Single-pulse arc production of

carbon nanotubes in ambient air” (submitted to Tel Aviv University in October 2005, in Hebrew), that as the pulse duration was lengthened from 7 to 12 $\mu$ s and then to 32  $\mu$ s, the density of the CNTs increased from  $\rho=0.01$  to 0.1 to 10 per  $\mu\text{m}^2$ , while the typical CNT length was relatively unchanged in the first step, but drastically decreased in the second step, from 11-28  $\mu\text{m}$  to 0.5-0.8  $\mu\text{m}$ . Thus the time length of the pulse plays a critical role in determining the density and length of the CNTs. In a potential application for CNTs, namely as electron emitters, it would be advantageous to have long CNTs, such that their field enhancement factor will be maximal, and a spacing  $l=\rho^{-1/2}$  approximately equal to the CNT length, such that there will be many emitters, but that they will not shield the electric field from their neighbor. These above data suggests that these parameters can be achieved in the pulse duration range indicated in the instant specification.

Furthermore, and quite significantly, by using considerably shorter pulses, the selectability of localizing nanotube placement is enabled—as taught in the instant specification and in an independent claim.

#### Deposition of CNTs on a Ni or other Metallic Workpiece

Takikawa teaches that the workpiece upon which the CNTs are deposited must contain carbon. In contrast, in one embodiment of the instant invention, CNTs were deposited on Ni workpieces, not containing carbon. In the specification of the instant invention, Table 1, items 15 and 16, it is shown that CNTs were probably produced on Ni workpieces (which did not contain carbon). At the time the instant patent application was filed, diagnostic tools available to the inventors were insufficient to conclude with absolute certainty that CNTs were produced under these circumstances. Subsequently the inventors, having better diagnostic tools, were able to verify that CNTs can be produced on Ni workpieces (i.e. with C present in the workpiece).

Scientific results to this effect were published by the inventors in:

N Parkansky, R L Boxman, B Alterkop, I. Zontag, Y Lereah, Z Barkay, "Single-Pulse Arc Production of Carbon Nanotubes in Ambient Air" J. Phys. D: Appl. Phys. Vol. 37, pp 2715-19, 2004, which is appended to this affidavit.

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements with the knowledge that the making of willfully false statements and the like is punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and may jeopardize the validity of any patent issuing from this patent application.

17 May 2007

DATE



Raymond Reuven Boxman

# RAYMOND L. BOXMAN

## CURRICULUM VITAE

March 2007

Date of Birth: June 9, 1946  
Place of Birth: Philadelphia, PA  
Family Status: Married, four children  
Military: Capt., Signal Corp., U.S. Army Reserve. R.O.T.C. 9/64 - 6/68  
Commissioned 6/68. Active Duty for Training 2/73 - 5/73,  
Ft. Gordon, Ga. (Signal Officers Basic Course).  
Seren (Res.) IAF

### EDUCATION:

Summer, 1963 Microbiology course, sponsored by National Science Foundation at La Salle College, Philadelphia, PA.

February 1969 S.M., S.B., in Electrical Engineering, Massachusetts Institute of Technology.  
Besides course in E.E., studied electives in physics & nuclear engineering.  
In co-op program with General Electric Co.  
Elected to following honorary societies: Eta Kappa Nu, Tau Beta Pi, and Sigma Xi.  
Thesis Title: Triggered Vacuum Interrupters .  
Thesis Supervisor: G.L. Wilson.

February, 1973 Ph.D., Massachusetts Institute of Technology,  
Department of Electrical Engineering.  
Major: Electromagnetic Fields & Matter, with emphasis on plasma physics.  
Minor: Bio-Electronics.  
Thesis Title: Interferometric Measurement of Electron & Vapor Densities in a High Current Vacuum Arc .  
Thesis Supervisor: G.L. Wilson.

### EXPERIENCE:

Summers 1963,'64,'65 METROMEDIA INC, Radio Station WIP, Philadelphia, PA.  
*Radio Engineer* - Duties included production of on-the-air show and remotely controlling two transmitters.

June - Sept 1966 GENERAL ELECTRIC CO. Missile & Space Div., Philadelphia, PA.  
*Co-op Student* - Aided in development of miniaturized capacitance type pressure transducer for space applications. Designed electronic signal processor for transducer. Experience in feedback and control, bridge circuits, transducers, operational amplifiers, telemetry systems, and integrated circuits.

Feb - June 1967 RESEARCH LABORATORY OF ELECTRONICS (M.I.T.), Cambridge, MA. *Student* - Developed scheme for measuring diamagnetism of after glow beam discharge plasma. Scheme compensated for magnetic flux diffusion through metal vessel, and for generator noise in the imposed magnetic field.

**RAYMOND LEON BOXMAN, Ph.D.**

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| June - Sept 1967 | GENERAL ELECTRIC CO., Missile and Space Div., Valley Forge, PA.<br><i>Co-op Student</i> - Conducted research on utilizing positive column of plasma glow discharge to simulate re-entry plasma conditions, and their effect on microwave transmission.                                                                                                                                                                                                                                                                                                                                                                                      |
| Feb - Sept 1968  | GENERAL ELECTRIC CO., Power Transmission Div., Philadelphia, PA.<br><i>Research Engineer</i> , (co-op assignment) - Conducted research on triggered vacuum interrupters, a device for switching high power electrical currents. Investigated effects of contact and trigger voltages, circuit, trigger material, contact separation and magnetic field on triggering characteristics. Studied photographs of arc, waveshapes, and device parts to propose triggering theory. Experience in metal vapor arcs, pulse circuits, vacuum technology, high speed photography, and material processing. Research formed basis for Master's thesis. |
| 1968 - 1970      | M.I.T. , Cambridge, MA.<br><i>Teaching Assistant</i> - Conducted classes, tutorials, demonstrations and graded papers in third and fourth year courses in electromagnetics, electromechanics, and signals and systems analysis. Graded papers in graduate courses in plasma dynamics and microwave circuits.                                                                                                                                                                                                                                                                                                                                |
| June-Sept 1969   | REHOBOTH INSTRUMENTS LTD , Rehoboth, Israel.<br>Conducted feasibility study of use of SEC television system for recording x- ray crystallography data for computer analysis.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1970 - 1971      | MAGNETIC CORPORATION OF AMERICA , Cambridge, MA.<br><i>Consultant</i> - aided in feasibility study of M.H.D. power generation for a particular application.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 1970-1973        | ELECTRIC POWER SYSTEMS ENGINEERING LABORATORY (M.I.T.) , Cambridge, MA.<br><i>Research Assistant</i> - Conducted research which formed basis for Ph.D. thesis. Duties included design of vacuum chamber, laser, interferometer, vibration isolation system and pulse circuits. Measured electron & copper vapor densities by infrared and optical interferometry in a copper vapor arc such as those which occur in vacuum switches. Supervised undergraduate laboratory and thesis projects.                                                                                                                                               |
| 1973-1975        | GENERAL ELECTRIC CO. Power Delivery Group, Philadelphia, PA.<br><i>Sr. Research Engineer</i> - Conducted development projects in vacuum circuit breakers & research in metal vapor arcs. Research included measuring anode surface temperature during anode spot formation by spectral radiometry, theoretical analysis of anode spot formation mechanisms, and studying the motion of high current vacuum arcs in magnetic fields.                                                                                                                                                                                                         |
| 1975 to present  | TEL AVIV UNIVERSITY, School of Engineering, Dept. of Interdisciplinary Studies.<br><i>Professor of Electrical and Electronic Engineering</i> - Instruct courses in electromagnetic theory, circuits, lasers, thin films, technical writing and electrical discharges in gases. Conduct research and supervise graduate student research in electrical discharge physics and applications, and metallurgical and thin film coatings.                                                                                                                                                                                                         |
| 1979 to present  | <i>Consultant</i> - Consultant on coatings, thin films, plasmas and electrical discharge applications.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |



## **RAYMOND LEON BOXMAN, Ph.D.**

- Sept. 1981 - June 1982      UNIVERSITY OF SOUTH CAROLINA, Dept. of Electrical and Computer Engineering.  
*Visiting Associate Professor* - Instructed undergraduate course in engineering analysis, and graduate courses on electrical discharges. Graduate course on experimental techniques in plasma research presented state-wide via the USC television system. Conducted research and advised graduate students on electrical breakdown in vacuum in the USC High Voltage Laboratory.
- July-August 1982      BROWN BOVERI RESEARCH CENTER, Baden, Switzerland,  
*Visiting Scientist* - Advised on the framing, organization, set-up, and initiation of a coordinated experimental and theoretical research program on vacuum arc phenomena relevant in vacuum switchgear.
- 1989-1990      DREXEL UNIVERSITY, Philadelphia, PA,  
*Visiting Professor of Electrical and Computer Engineering* - Instructed graduate course on thin film technology and undergraduate courses in electromagnetic fields. Initiated research program on using vacuum arc deposition to produce high temperature superconducting films.
- July-August 1995      MULTI-ARC INC. Rockaway, N.J.,  
*Guest Scientist* - Conducted research on diamond-like carbon coatings.

### **MEMBERSHIPS:**

- ☐ Fellow of the Institute of Electrical & Electronics Engineers and the IEEE Nuclear & Plasma Sciences Society
- ☐ Society of Sigma Xi
- ☐ Israel Vacuum Society
- ☐ Israel Plasma Science and Technology Society

### **PROFESSIONAL AND UNIVERSITY ACTIVITIES:**

- October 1982      Publicity chairman and coordinator for video tape publication of invited lectures for the Xth International Symposium on Discharges and Electrical Insulation in Vacuum. (Columbia SC).
- Sept. 1983      Editor for vacuum arcs for special issue of the IEEE Transactions on Plasma Science entitled "Vacuum Discharge Plasmas".
- June 1983      Editor for vacuum arcs for special issue of IEEE Transactions on Electrical Insulation entitled "Insulation and Breakdown in Vacuum".
- 1981/2      While abroad on sabbatical, gave invited seminars on various vacuum arc topics at the State University of New York at Buffalo, University of Minnesota, Calor-Emag Company (Federal Republic of Germany), Westinghouse Research and Development Center, and the Oak Ridge National Laboratory.
- 1983      University administrative responsibility has included serving on engineering faculty computer committee, and on the executive committee of the university safety council. Chaired ad-hoc faculty committee for setting up infrastructure for VAX computers.
- 1984-86      Head, Department of Interdisciplinary Studies.
- 1986-1989      Faculty graduate education committee.
- 1990-1992      Faculty electrical engineering curriculum committee.
- 1986      Organizing committee chairman of the XIth International Symposium on Discharges and Electrical Insulation in Vacuum and proceedings editor.

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|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| October 1987   | Guest Editor, IEEE Transactions on Plasma Science, special issue on Vacuum Discharge Plasmas.                                                                                                            |
| February 1988  | Guest Editor, IEEE Transactions on Electrical Insulation, special issue on Insulation and Breakdown in Vacuum.                                                                                           |
| 1988-          | Member of the Permanent International Scientific Committee of the International Symposia on Discharges and Electrical Insulation in Vacuum. Secretary 1988-1994. Chairman - Awards Committee, 1989-1993. |
| 1988 -2006     | Associate Editor, IEEE Transactions on Plasma Science.                                                                                                                                                   |
| December, 1990 | Guest Editor, special issue of IEEE Transactions on Plasma Science on "Plasma Deposition".                                                                                                               |
| 1990-2004      | Member of the Hard Coatings and Vapor Deposition Technology Symposium Committee, Int. Conf. on Metallurgical Coatings and Thin Films.                                                                    |
| 1993-1996      | Faculty of Engineering graduate education committee                                                                                                                                                      |
| 1993-2000      | TAU appointments and promotions committee, for the Center for Technological Education (Holon).                                                                                                           |
| 1995-2000      | TAU equipment committee.                                                                                                                                                                                 |
| 1996-98        | Faculty of Engineering computer committee                                                                                                                                                                |
| 1997-2001      | Founder and First Chairman, Israel Plasma Science and Technology Society                                                                                                                                 |
| 1999-          | Member of the Editorial Board, Plasma Chemistry and Plasma Processing                                                                                                                                    |
| 2000-2002      | Chairman, Faculty of Engineering M.Sc. Committee                                                                                                                                                         |
| 1999-          | Head, Faculty of Engineering Materials Engineering Program                                                                                                                                               |
| 2002-3         | Chairman, <i>ad hoc</i> committee investigating Faculty of Engineering organization                                                                                                                      |
| 2002-4         | Member, Tel Aviv University M.Sc. Committee                                                                                                                                                              |
| Feb 2004       | Chairman, 7 <sup>th</sup> Israeli Conference on Plasma Science and Applications                                                                                                                          |
| Oct 2004 -     | Chairman, Department of Interdisciplinary Studies, School of Electrical Engineering                                                                                                                      |
| Oct 2004 -     | Chairman, Faculty of Engineering Research Committee                                                                                                                                                      |
| Feb 2006       | Chairman, International Conference on Superhard Coatings                                                                                                                                                 |

**Honors :**

|                |                                                                                                                                                                                                                                                                                                                                                     |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| October 1984   | Boris and Renee Joffe Award, presented by the International Union for Electrodeposition and Surface Finishing at the 11th World Congress on Metal Finishing (Interfinish '84).                                                                                                                                                                      |
| January 1989   | Fellow of the Institute of Electrical and Electronics Engineers, for "Advances in Vacuum Arc Theory and its Applications".                                                                                                                                                                                                                          |
| September 2000 | Walter Dyke Award, by the Permanent International Scientific Committee of the International Symposia on Discharges and Electrical Insulation in Vacuum, for "his outstanding body of work in the field of electrical discharges in vacuum, in particular for his contributions to the physics, technology, and applications of vacuum arc plasmas". |

LIST OF PUBLICATIONS.

Articles in Journals

1. R.L. Boxman, "Interferometric Measurement of Electron and Vapor Densities in a High-Current Vacuum Arc," *Journal of Applied Physics*, Vol. 45, pp. 4835-4846, 1974.
2. R.L. Boxman, "Measurement of Anode Surface Temperature During a High Current Vacuum Arc," *Journal of Applied Physics*, Vol. 46, pp. 4701-4704, 1975.
3. R.L. Boxman, "Magnetic Constriction Effects in High-Current Vacuum Arcs Prior to the Release of Anode Vapor," *Journal of Applied Physics*, Vol. 48, pp. 2338-2345, 1977.
4. R.L. Boxman, "High Current Vacuum Arc Column Motion on Rail Electrodes," *Journal of Applied Physics*, Vol. 48, pp. 1885-1890, 1977.
5. R.L. Boxman, "Triggering Mechanisms in Triggered Vacuum Gaps," *IEEE Trans. Electron Devices*, Vol. ED-24, 122-128, 1977.
6. R.L. Boxman, J.H. Harris, and A. Bless, "Time Dependence of Anode Spot Formation Threshold Current in Vacuum Arcs," *IEEE Trans. Plasma Science*, Vol. PS-6, pp. 233-238, 1978.
7. R.L. Boxman and M.L. Sloan, "A Scanning Technique for Obtaining Linear Fringe Shift Readout from a High Resolution Interferometer," *Applied Optics*, Vol. 17, pp. 2794-2797, 1978.
8. R.L. Boxman and D.J. Shlien, "Interferometric Technique for Measuring the Refractive Index Variation of a Liquid with Temperature," *Review of Scientific Instruments*, Vol. 49, pp. 861-863, 1978.
9. R.L. Boxman and D.J. Shlien, "Interferometric Measurement Technique for the Temperature Field of Axisymmetric Buoyant Phenomena," *Applied Optics*, Vol. 17, pp. 2788-2793, 1978.
10. D.J. Shlien and R.L. Boxman, "Temperature Field Measurement of an Axisymmetric Laminar Plume," *Phys. Fluids*, Vol. 22, pp. 631-634, 1979.
11. D.J. Shlien and R.L. Boxman, "Laminar Starting Plume Temperature Field Measurement," *Int. J. Heat and Mass Transfer*, Vol. 24, pp. 919-931, 1981.
12. R.L. Boxman and S. Goldsmith, "Excited State Densities in a Multi-Cathode-Spot Al Vacuum Arc, I. Spectroscopic Measurements," *Journal of Applied Physics*, Vol. 51, pp. 3644-3656, 1980.
13. S. Goldsmith and R.L. Boxman, "Excited State Densities in a Multi-Cathode-Spot Al Vacuum Arc, II. Theoretical Approach," *Journal of Applied Physics*, Vol. 51, pp. 3657-3663, 1980.
14. V.A. Finch, R. Dmiel, R. Boxman, A. Shkolnik and C. Taylor, "Why Black Goats in Hot Deserts? Effects of Coat Color on Heat Exchange of Wild and Domestic Goats," *Physiol. Zool.* Vol. 53, pp. 19-25, Jan 1980.
15. R.L. Boxman and S. Goldsmith, "The Interaction Between Plasma and Macroparticles in a Multi-Cathode-Spot Vacuum Arc," *Journal of Applied Physics*, Vol. 52, pp. 151-162, 1981.
16. R.L. Boxman, E. Gerby and S. Goldsmith, "Behavior of High-Current Vacuum Arc Between Hollow Cylindrical Electrodes in a Radial Magnetic Field," *IEEE Trans. Plasma Sci. (Special Issue on Arc Plasmas)* Vol. PS-8, pp. 308-313, 1980.
17. S. Goldsmith, S. Shalev, and R.L. Boxman, "Excited State Densities in a Multi-Cathode-Spot Cd Vacuum Arc," *Physica*, Vol. 104C, pp. 107-115, 1981.
18. S. Shalev, S. Goldsmith and R.L. Boxman, "Population Inversion of  $\text{Cd}^+$  Excited-States in the Plasma of Cadmium Vapor Vacuum Arc," *IEEE J. Quant. El.*, Vol. QE-17, pp. 8-10, 1981.
19. S. Goldsmith and R.L. Boxman, "Coulomb Approximation Calculations of Transition Probabilities in the Transition Array  $3d^9 4d-3d^4 4f$  in Cu II", *J. Phys. B: Atom. Molec. Phys.* Vol. 14, pp. 3031-3036, 1981.

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20. R. L. Boxman and S. Goldsmith, "A Model of the Anode Region in a Uniform Multi-Cathode-Spot Vacuum Arc", *Journal of Applied Physics*, Vol. 54, pp. 592-602, 1983.
21. S. Shalev, S. Goldsmith, and R.L. Boxman, "Absorption Effects of the Cd II 4416 A Line in a Cadmium Vacuum Arc Plasma", *Journal of Applied Physics*, Vol. 53, pp. 6736-6741, 1982.
22. F.T. Warren, J.M. Wilson, J.E. Thompson, R.L. Boxman, and T. Sudarshan, "Vacuum Switch Trigger Delay Characteristics", *IEEE Trans. Plasma Sci.* (special issue on Plasma Switching), PS-10, pp. 298-301, 1982.
23. J.M. Wilson, R.L. Boxman, and J.E. Thompson, "Breakdown Time of a Triggered Vacuum and Low-Pressure Switch", *IEEE Trans. Electrical Insulation* Vol. EI-18, pp. 238-242, 1983.
24. R. L. Boxman, S. Goldsmith, I. Izraeli, and S. Shalev, "A Model of the Multi-Cathode-Spot Vacuum Arc", *IEEE Trans. Plasma Sci.* Vol. PS-11, pp. 138-145, 1983.
25. S. Goldsmith, S. Shalev and R.L. Boxman, "Anode Melting in a Multi Cathode-Spot Vacuum Arc", *IEEE Trans. Plasma Sci.*, Vol. PS-11, pp. 127-132, 1983.
26. S. Shalev, S. Goldsmith and R.L. Boxman, "In-situ Determination of Macroparticles Velocity in a Copper Vacuum Arc", *IEEE Trans. Plasma Sci.*, Vol. PS-11, pp. 146-151, 1983.
27. I. Izraeli, S. Goldsmith and R.L. Boxman, "The Influence of the Self Magnetic-Field on the Steady State Current Distribution in an Axially Flowing Conducting Medium", *IEEE Trans. Plasma Sci.* Vol. PS-11, pp. 160-164, 1983.
28. F.T. Warren, R.L. Boxman, J.E. Thompson and T. Sudarshan, "Current Evolution in a Pulsed Overstressed Radial Vacuum Gap", *IEEE Trans. Electrical Insulation*, Vol. EI-18, pp. 226-229, 1983.
29. R. Lee, T. Sudarshan, J.E. Thompson, G.R. Nagabhoshana and R.L. Boxman, "Predischage Current Measurement in Vacuum Gaps Bridged with Plexiglass Insulators", *IEEE Trans. Electrical Insulation*, Vol. EI-18, pp. 280-286, 1983.
30. S. Goldsmith, Y. Bresler and R.L. Boxman, "Spectroscopic Study of Excited-State Densities in a Zn Vacuum-Arc Plasma", *Journal of Applied Physics*, Vol. 54, pp. 5691-5697, 1983.
31. S. Shalev, S. Goldsmith, R. Boxman, S. Einav, A. Avidor, "Laser Doppler Annemometry: A method for measuring macroparticle dynamics in vacuum arcs", *J. Phys. E: Scientific Instruments*, Vol. 17, pp. 56-61, 1984.
32. S. Shalev, R.L. Boxman, S. Goldsmith, "Velocities & Emission Rates of Cathode Produced Molybdenum Macroparticles in a Vacuum Arc". *Journal of Applied Physics*, Vol. 58, pp. 2503-2507, 1985.
33. I. Israeli, A. Whitman, R.L. Boxman and S. Goldsmith, "Asymptotic Analysis of the Steady State Current Flow in a Uniform Multi-Cathode-Spot Generated Vacuum Arc Plasma Flow". *IEEE Trans. Plasma Science*, Vol. PS-13, pp. 281-284, 1985.
34. B. Gellert, E. Schade and R.L. Boxman, "Time and Spatially Resolved Spectroscopy of the Plasma State Prior to and During Anode Spot Formation in High Current Vacuum Arcs". *IEEE Trans. Plasma Science*, Vol. PS-13, pp. 265-268, 1985.
35. S. Shalev, R.L. Boxman and S. Goldsmith, "Macroparticle Dynamics During Multi-Cathode-Spot Vacuum Arcs". *IEEE Trans. Plasma Science*, Vol. PS 14, pp. 59-62, 1986.
36. R.L. Boxman, S. Goldsmith, S. Shalev, H. Yaloz and N. Brosh, "Fast Depositions of Metallurgical Coatings and Production of Surface Alloys Using a Pulsed High Current Vacuum Arc". *Thin Solid Films*, Vol. 139, pp. 41-52, 1986.
37. G. Disatnik, R.L. Boxman, S. Goldsmith, "Characteristics of macro particle emission from a high current density multi-cathode-spot pulsed vacuum arc", *IEEE Trans. Plasma Sci.*, Vol. PS-15, pp. 520-523, 1987.
38. S. Goldsmith, R.L. Boxman, E. Sapir, Y. Cohen, H. Yaloz, N. Brosh, "Distribution of peak temperature and energy flux on the surface of the anode in a multi-cathode-spot pulsed vacuum arc", *IEEE Trans. Plasma Sci.*, Vol. PS- 15, pp. 510-514, 1987.

**RAYMOND LEON BOXMAN, Ph.D.**

39. I. Izraeli, R.L. Boxman, S. Goldsmith, "The current distribution and the magnetic pressure profile in a vacuum arc subjected to an axial magnetic field", IEEE Trans. Plasma Sci., Vol. PS-15, pp. 502-505, 1987.
40. S. Bababeygy, R.L. Boxman, S. Goldsmith, "Corrosion evaluation of very rapid high-current vacuum arc coatings", IEEE Trans. Plasma Sci., Vol. PS-15, pp. 599-602, 1987.
41. R.L. Boxman and S. Goldsmith, "Cathode-spot arc coatings: physics, deposition and heating rates, and some examples", Surface and Coatings Technology, Vol. 33, pp. 153-167, 1987.
42. Y. Cohen, R.L. Boxman and S. Goldsmith, "Angular distribution of ion current emerging from an aperture anode in a vacuum arc", IEEE Trans. Plasma Sci., Vol. PS-17, pp. 713-716, 1989.
43. R.L. Boxman and S. Goldsmith, "A model for a uniform steady-state vacuum arc with a hot anode", IEEE Trans. Plasma Sci., Vol. PS-17, pp. 661-665, 1989.
44. R.L. Boxman and S. Goldsmith, "Principles and applications of vacuum arc coatings", IEEE Trans. Plasma Sci., Vol. PS-17, pp. 705-712, 1989.
45. R. Rosenbaum, M. Ben-Shlomo, S. Goldsmith and R.L. Boxman, "Low temperature electronic transport properties of W, Mo, Ta and Zr thin films", Phys. Rev. B, Vol. 39, pp. 10009-10019, 1989.
46. U. Ghera, R.L. Boxman, S. Ruschin and H. Kleinman, "Laser induced electron source in a vacuum diode", Journal of Applied Physics, Vol. 66, pp. 4425-4430, 1989.
47. R.L. Boxman and S. Goldsmith, "Momentum interchange between cathode spot plasma jets and background gases and vapors and its implication on vacuum arc anode spot development", IEEE Trans. Plasma Sci. Vol. PS-18, pp. 231-236, 1990.
48. R.L. Boxman and S. Goldsmith, "Characterization of a 1 kA vacuum arc plasma gun for use as a metal vapor deposition source", Surface and Coatings Technology, Vol. 43/44, pp. 1024-1034, 1990.
49. R.L. Boxman and S. Goldsmith, "Macroparticle Contamination in Cathodic Arc Coatings: Generation, Transport, and Control", Surface and Coatings Technology, Vol. 52, pp. 39-50, 1992.
50. A. Ben-Shalom, R.L. Boxman and S. Goldsmith, "Ion current collected at various distances and argon background pressures in a copper vacuum arc", IEEE Trans. Plasma Sci. Vol. 21, pp. 435-439, 1993.
51. N. Parkansky, I. Beilis, R.L. Boxman and S. Goldsmith, "Electrode erosion during pulsed arcing", IEEE Trans. Plasma Sci. Vol. 21, pp. 458-462, 1993.
52. R.L. Boxman and S. Goldsmith, "Mass and surface conductivity gain on polymer surfaces metalized using vacuum arc deposition", Thin Solid Films, Vol. 236, pp. 341-346, 1993.
53. A. Ben-Shalom, L. Kaplan, R.L. Boxman, M. Nathan and S. Goldsmith, "SnO<sub>2</sub> transparent conductor films produced by a filtered vacuum arc", Thin Solid Films, Vol. 236, pp. 20-26, 1993.
54. N. Parkansky, R.L. Boxman and S. Goldsmith, "Development and application of pulsed air arc deposition", Surface and Coatings Technology, Vol. 61, pp. 268-273, 1993.
55. V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, "Influence of an external magnetic field on cathode spot motion and coating deposition using filtered arc evaporation", Surface and Coatings Technology, Vol. 68/69, pp. 146-151, 1994.
56. L. Kaplan, A. Ben-Shalom, R.L. Boxman, S. Goldsmith, U. Rosenberg, M. Nathan, "Annealing and Sb-Doping of Sn-O films produced by filtered vacuum arc deposition: structure and electro-optical properties", Thin Solid Films, Vol. 253, pp. 1-8, 1994.
57. D. Arbilly, R.L. Boxman, S. Goldsmith, A. Rothwarf, L. Kaplan, "Amorphous Si thin films prepared by vacuum arc deposition", Thin Solid Films, Vol. 253, pp. 62-66, 1994.

**RAYMOND LEON BOXMAN, Ph.D.**

58. N. Parkansky, R.L. Boxman, S. Goldsmith, Y. Rosenberg, A. Ben-Shalom, L. Kaplan, D. Arbilly, "Improvement of thin film semi-conductor conductivities using a transverse current during deposition", *Surface and Coatings Technology*, Vol. 68/69, pp. 320-324, 1994.
59. K. Pourrezaei, I. Shevets, M. Delaurentis, R.L. Boxman, R.B. Beard, N. Croitoru, M. Mukhtar, D.A. Logan, R. Rastogi, "Development of antimicrobial and antithrombogenic coatings for inside and outside of medical catheters", *Surface and Coatings Technol.*, Vol. 68/69, pp. 669-674, 1994.
60. R.L. Boxman, S. Goldsmith, A. Ben-Shalom, L. Kaplan, D. Arbilly, E. Gidalevich, V.N. Zhitomirsky, A. Ishaya, M. Keidar, I. Beilis, "Filtered vacuum arc deposition of semi-conductor thin films", *IEEE Trans. Plasma Sci.*, Vol. 23, pp. 939-944, 1995.
61. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "Non-stationary macroparticle charging in an arc plasma jet", *IEEE Trans. Plasma Sci.*, Vol. 23, pp. 902-908, 1995.
62. H. Rosenthal, I. Beilis, S. Goldsmith and R.L. Boxman, "Heat fluxes during the development of hot anode vacuum arc", *J. Phys. D.: Applied Physics*, Vol. 28, pp. 353-363, 1995.
63. V.N. Zhitomirsky, R.L. Boxman and S. Goldsmith, "Unstable arc operation and cathode spot motion in a magnetically filtered vacuum arc deposition system", *J. Vac. Sci. Technol. A*, Vol. 13, pp. 2233-2240, 1995.
64. L. Kaplan, V.N. Zhitomirsky, R.L. Boxman and S. Goldsmith, "Arc behavior during filtered vacuum arc deposition of Sn-O thin films", *Surface and Coatings Technology*, Vol. 76/77, pp. 181-189, 1995.
65. V.N. Zhitomirsky, L. Kaplan, R.L. Boxman and S. Goldsmith, "Ion current distribution in a filtered vacuum arc deposition system", *Surface and Coatings Technology*, Vol. 76/77, pp. 190-196, 1995.
66. N. Parkansky, R. Rosenbaum, Y. Rosenberg, R.L. Boxman and S. Goldsmith, "Influence of transverse current during In-O vapor deposition", *Surface and Coatings Technology*, Vol. 76/77, pp. 197-201, 1995.
67. N. Parkansky, R.L. Boxman, S. Goldsmith and Y. Rosenberg, "Corrosion resistance of Zn-coatings produced by pulsed-air arc deposition", *Surface and Coatings Technology*, Vol. 76/77, pp. 352-357, 1995.
68. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "Transport of macroparticles in magnetized plasma ducts", *IEEE Trans. Plasma Sci.*, Vol. 24, pp. 226-234, 1996.
69. U. Kinrot, S. Goldsmith and R.L. Boxman, "Monochromatic imaging of cathodic arc plasma", accepted for publication in *IEEE Trans. Plasma Sci.*, (special issue on plasma imaging) Vol. 24, pp. 71-72, 1996.
70. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "2D expansion of the low-density interelectrode vacuum arc plasma jet in an axial magnetic field", *J. Phys. D: Appl. Phys.*, Vol. 29, pp. 1973-1983, 1996.
71. M. DeLaurentis, R.L. Boxman, K. Pourrezaei, I. Shvets, R. Beard and M. Muhktar, "Reduction of intravascular catheter infection using Ag and Ag/Pt coatings", accepted for publication in *J. Infectious Disease*.
72. B. Alterkop, E. Gidalevich, S. Goldsmith and R.L. Boxman, "Vacuum arc plasma jet propagation in a toroidal duct", *J. Appl. Phys.*, Vol. 79, pp. 6791-6802, 1996.
73. R.L. Boxman, S. Goldsmith, V.N. Zhitomirsky, B. Alterkop, E. Gidalevich, I. Beilis and M. Keidar, "Recent progress in filtered vacuum arc deposition", *Surf. Coat. Technol.* Vol. 86-87, pp. 243-253, 1996.
74. N. Parkansky, B. Alterkop, R. Rosenbaum, R.L. Boxman and S. Goldsmith, "The effect of post-deposition transverse current injection on amorphous indium oxide film conductivity", *Thin Solid Films*, Vol. 333, pp 150-156, 1998.
75. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "Macroparticle interaction with a substrate in cathodic vacuum arc deposition", *Surf. Coat. Technol.* Vol. 86-87, pp. 415-420, 1996.

**RAYMOND LEON BOXMAN, Ph.D.**

76. V.N. Zhitomirsky, U. Kinrot, B. Alterkop, R.L. Boxman and S. Goldsmith, "Influence of gas pressure on the ion current distribution in a filtered vacuum arc deposition system", *Surf. Coat. Technol.* Vol. 86-87, pp. 263-270, 1996.
77. L. Kaplan, I. Rusman, R.L. Boxman, S. Goldsmith, M. Nathan, and E. Ben-Jacob, "STM and XPS Study of Filtered Vacuum Arc Deposited Sn-O Films After Rapid Thermal Annealing", *Thin Solid Films* Vol. 290-291, pp. 355-361, 1996.
78. H. Rosenthal, I. Beilis, S. Goldsmith, and R.L. Boxman, "A spectroscopic investigation of the development of a hot-anode vacuum arc", *J. Phys. D.: Appl. Phys.* Vol. 29, pp. 1245-1259, 1996.
79. B. Alterkop, V.N. Zhitomirsky, S. Goldsmith, and R.L. Boxman, "Propagation of vacuum arc plasma beam in a toroidal filter", *IEEE Trans. Plasma Sci.*, Vol. 24, pp 1371-1377, 1996.
80. B. Alterkop, N. Parkansky, R.L. Boxman, S. Goldsmith. "Influence of A Parallel Electric Field on The Conductivity of A Growing Indium Oxide Film", *Thin Solid Films* Vol. 290-291, pp. 10-12, 1996.
81. B. Alterkop, E. Gidalevich, S. Goldsmith and R.L. Boxman. "Numerical calculation of plasma beam propagation in a toroidal duct with magnetized electrons and unmagnetized ions" *J. Physics D: Applied Physics* Vol. 29, pp. 1-7, 1996.
82. E. Halachmi, O. Levi, L. Kronik, and R.L. Boxman, "Development of Latent Fingerprints Using a Corona Discharge", *J. Forensic Sci.* 42, pp. 833-841, 1997.
83. M. Keidar, I. Beilis, R.L. Boxman, and S. Goldsmith, "Voltage of the vacuum arc with a ring anode in an axial magnetic field", *IEEE Trans. Plasma Sci.*, Vol. 25, pp. 580-585, Aug. 1997.
84. R.L. Boxman, S. Goldsmith, and A. Greenwood, "Twenty-five years of progress in vacuum arc research and utilization", *IEEE Trans. Plasma Sci.*, Vol. 25, pp. 1174-1186, Dec. 1997.
85. M. Keidar, I. Beilis, R. Aharonov, D. Arbilly, R.L. Boxman, S. Goldsmith, "Macroparticle distribution in a quarter-torus plasma duct of a filtered vacuum arc deposition system", *J. Phys. D: Appl. Phys.* Vol. 30, pp. 2972-2978, 1997.
86. N. Parkansky, B. Alterkop, W. Schuster, R.L. Boxman, and S. Goldsmith "Vacuum arc deposition of Ti-films with transverse current injection", *J. Appl. Phys.* Vol. 82, pp. 4062-66, 1997.
87. I. Grimberg, V.N. Zhitomirsky, N. Parkansky, A. Matthews, A. Wilson, R.L. Boxman, B.Z. Weiss, and S. Goldsmith, "Structure and Tribological Properties of Thin Vacuum Arc Coatings on Polysulfone", *Surf. Coat. Technol.* Vol. 94/95, pp. 213-219, 1997.
88. V.N. Zhitomirsky, I. Grimberg, R.L. Boxman, B.Z. Weiss, N.A. Travitzky and S. Goldsmith, "Vacuum Arc Deposition and Microstructure of ZrN-Based Coatings", *Surf. Coat. Technol.* Vol. 94/95, pp. 207-212, 1997.
89. V.N. Zhitomirsky, I. Grimberg, I. Rapoport, N.A. Travitsky, R.L. Boxman, S. Goldsmith, A. Raihel, I. Lapsker, and B.Z. Weiss, "Structure and Mechanical Properties of Vacuum Arc Deposited NbN Coatings", *Thin Solid Films* Vol. 326, pp 134-142, 1998.
90. I.I. Beilis, M. Keidar, R.L. Boxman, S. Goldsmith, "Nonequilibrium Macroparticle Charging in Low-Density Discharge Plasmas", *IEEE Trans. Plasma Sci.*, Vol. 25, pp. 346-352, 1997.
91. V.N. Zhitomirsky, R.L. Boxman and S. Goldsmith, " Ion current distribution in a toroidal duct of a filtered vacuum arc deposition system", *IEEE Trans. Plasma Sci.*, Vol. 25, No 5, pp. 665-669, 1997.
92. I. Beilis, M. Keidar, R.L. Boxman, and S. Goldsmith, "Theoretical study of plasma expansion in a magnetic field in a disc anode vacuum arc", *J. Appl. Phys.* Vol. 83, pp. 709-717, 1998.
93. E. Gidalevich, R.L. Boxman, and S. Goldsmith, "Theory and modeling of the interaction of two parallel supersonic plasma jets", *J. Phys. D: Appl. Phys.*, Vol. 31, pp. 304-311, 1998.
94. I.I. Beilis, M. Keidar, R.L. Boxman and S. Goldsmith. "Macroparticle separation and plasma collimation in positively biased ducts in filtered vacuum arc deposition systems", *J. Appl. Phys.*, Vol. 85, pp. 1358-1365, 1999.



**RAYMOND LEON BOXMAN, Ph.D.**

95. I. Grimberg, V.N. Zhitomirsky, R.L. Boxman, S Goldsmith, and B.Z. Weiss, "Multicomponent Ti-Zr-N and Ti-Nb-N coatings deposited by vacuum arc", *Surf. Coat. Technol.* Vol. 108-109, pp. 154-159, 1998.
96. V.N. Zhitomirsky, I. Grimberg, M.C. Joseph, R.L. Boxman, B.Z. Weiss, A. Matthews, and S. Goldsmith, "Vacuum Arc Deposition of Metal/Ceramic Coatings on Polymer Substrates", *Surf. Coat. Technol.* Vol. 108-109, pp. 160-165, 1998.
97. N. Parkansky, I. Beilis, L. Rapoport, R.L. Boxman, S. Goldsmith, and Y. Rosenberg, "Electrode erosion and coating properties in pulsed air arc deposition of WC-based alloys", *Surface and Coatings Technology*, Vol. 105, pp. 130-134, 1998.
98. B. Alterkop, E. Gidalevich, S. Goldsmith, and R.L. Boxman, "Propagation of a magnetized plasma beam in a toroidal filter", *J. Phys. D: Appl. Phys.* Vol. 31, pp. 873-879, 1998.
99. L. Rapoport, A. Rayhel, I. Lapsker, N. Parkansky, R.L. Boxman, S. Goldsmith, "The effect of electricity on the mechanical properties of WC - Co alloy", *J. Mechan. Behav. of Materials*, Vol. 9 pp. 267-276, 1998.
100. N. Parkansky, I. Beilis, R.L. Boxman, S. Goldsmith, Yu. Rosenberg, "Anode mass loss during pulsed air arc deposition", *Surface and Coating Technology*, Vol. 108-109, pp.253-256, 1998.
101. N. Parkansky, B. Alterkop, S. Goldsmith, R.L. Boxman, Yu. Rosenberg, "The effect of transverse current injection during air annealing of the formation of oxides in thin Ti films", *J. Appl. Phys.*, Vol. 85, pp. 498-500, 1999.
102. I. I. Beilis, R. L. Boxman, and S. Goldsmith. "Steady-state model of a refractory hot anode vacuum Arc", *J. Phys. D: Appl. Phys.*, Vol. 32, pp.153-158, 1999.
103. I.I. Beilis, M. Keidar, R.L. Boxman, and S. Goldsmith, "Effect of macroparticle separation in positively biased ducts in the filtered vacuum arc deposition systems", *Surface and Coatings Technology*, Vol. 108-109, pp.148-153, 1998.
104. R Ben-Ami, V N Zhitomirsky, R L Boxman and S Goldsmith, "Plasma distribution in a triple-cathode vacuum arc deposition apparatus" *Plasma Sources Sci. Technol.*, 8, No 3 (1999), pp.355-362.
105. V.N. Zhitomirsky, I. Grimberg, L. Rapoport, N.A. Travitzky, R.L. Boxman, S. Goldsmith and B.Z. Weiss, "Vacuum arc deposition of TiN, NbN and TiN/NbN multilayer coatings", *Surface and Coatings Technology*, Vol. 120-121, pp. 2199-225, 1999.
106. V.N. Zhitomirsky, I. Grimberg, M.C. Joseph, R.L. Boxman, A. Matthews and B.Z. Weiss, "Vacuum arc deposition of conductive wear resistant coatings on polymer substrates", *Surface and Coatings Technology*, Vol. 120-121, pp. 373-377, 1999.
107. R.L. Boxman, V.N. Zhitomirsky, I. Grimberg, L. Rapoport, S. Goldsmith, and B.Z. Weiss, "Structure and hardness of vacuum arc deposited multi-component nitride coatings of Ti, Zr and Nb", *Surface and Coatings Technology*, Vol. 125, pp. 257-262, 2000.
108. I.I. Beilis, M. Keidar, R.L. Boxman, S. Goldsmith, J. Heberlein, and E. Pfender, "Radial plasma flow in a hot anode vacuum arc", *J. Appl. Phys.*, Vol. 86, pp. 114-119, 1999.
109. N. Parkansky, B. Alterkop, S. Goldsmith, R.L. Boxman, Yu Rosenberg, and Z. Barkay, "The effect of an electric field on the high temperature oxidation of copper in air", *Surface and Coatings Technology*, Vol. 120-121, pp. 668-671, 1999.
110. N. Parkansky, B. Alterkop, S. Goldsmith, and R.L. Boxman, "The effect of applying an electric field during air annealing on the resistance of Ti films", *J. Phys. D: Appl. Phys.* Vol. 32, pp. 1503-5, 1999.
111. E. Gidalevich, S. Goldsmith, R.L. Boxman, "Shock front formation by two isotropic supersonic plasma jets", *IEEE Transactions on Plasma Science*, Vol. 27, No. 4, 1045-1048, 1999.
112. E. Gidalevich, S. Goldsmith, R.L. Boxman, Interaction of two dissimilar plasma jets, *IEEE Transaction on Plasma Science*, 27, No. 4, 1164-1168, 1999.
113. V. N. Zhitomirsky, I. Grimberg, L. Rapoport, R. L. Boxman, N. A. Travitzky, S. Goldsmith and B.Z. Weiss "Bias voltage and incidence angle effects on the structure and properties of



**RAYMOND LEON BOXMAN, Ph.D.**

- vacuum arc deposited TiN coatings", *Surface Coat. Technol.*, Vol. 133-134 (2000), p.p. 114-120.
114. I.I. Beilis, M. Keidar, R.L. Boxman, and S. Goldsmith, "Interelectrode plasma parameters and plasma deposition in a hot refractory anode vacuum arc", *Physics of Plasmas* 7, p.p. 3068-3076, 2000.
115. I.I. Beilis, R.L. Boxman, S. Goldsmith, and V.L. Paperny, "Ion acceleration in the radially expanding plasma of the hot refractory anode vacuum arc", *Appl. Phys. Lett.* 75, pp. 2734-2736, 2000.
116. I.I. Beilis, R.L. Boxman, S. Goldsmith, and V.L. Paperny, "Radially expanding plasma parameters in a hot refractory anode vacuum arc", *J. Appl. Phys.* 88, p.p. 6224-6231, 2000.
117. N. Parkansky, B. Alterkop, S. Goldsmith, R.L. Boxman, H. Wulff, M. Quaas, and A. Quade, "Nano-organization of thin titanium films by an electric field during vacuum arc deposition", *Thin Solid Films* 377-378, pp. 507-511, 2000.
118. N. Parkansky, V.N. Zhitomirsky, B. Alterkop, S. Goldsmith, R.L. Boxman, Y. Rosenberg, and Z. Barkay, "Effect of Transverse Current Injection During Vacuum Arc Deposition of TiN", *Surf. Coat. Technol.* Vol. 133-4, pp. 101-5, 2000.
119. E. Gidalevich, S. Goldsmith, R.L. Boxman, "Vacuum arc plasma jet interaction with neutral ambient gas" *J. Phys. D: Appl. Phys.* Vol. 33, pp. 2598-2604, 2000.
120. I.I. Beilis, S. Goldsmith, R.L. Boxman, "The hot refractory anode vacuum arc: a new plasma source for metallic film deposition", *Surface Coat. Technol.*, Vol. 133-134 (2000), p.p. 114-120.
121. L. Rapoport, N. Parkansky, I. Lapsker, A. Rayhel, B. Alterkop, R.L. Boxman, S. Goldsmith, L. Burstain, "Effect of transverse current injection on the tribological properties of WC cemented carbide", *Wear* Vol. 249, pp. 1-5, 2001.
122. E. Gidalevich, R.L. Boxman, S. Goldsmith "Applicability of the Hydrodynamic Approximation to Current-Carrying Plasma Jets During Their Radial Expansion", *IEEE Trans. Plasma Sci.* Vol. 29, pp. 371-376, 2001.
123. E. Gidalevich, S. Goldsmith, R.L. Boxman, "Modelling of nonstationary vacuum arc plasma jet interaction with a neutral background gas", *J. Appl. Phys.* Vol. 90, pp. 4355-4360, 2001.
124. R.L. Boxman, "Early History of Vacuum Arc Deposition", *IEEE Trans. Plasma Sci.* Vol. 29, pp. 759-761, 2001.
125. R.L. Boxman, "Recent Developments in Vacuum Arc Deposition", *IEEE Trans. Plasma Sci.* Vol. 29, pp. 762-767, 2001.
126. V.N. Zhitomirsky, O. Zarchin, S.G. Wang, R.L. Boxman, and S. Goldsmith, "Ion Current Produced by a Vacuum Arc Carbon Plasma Source", *IEEE Trans. Plasma Sci.* Vol. 29, pp. 776-780, 2001.
127. E. Gidalevich, S. Goldsmith, R.L. Boxman, "Supersonic Plasma Flow Near a Point Charge", *J. Phys. D.: Applied Physics* Vol. 35, pp. 199-204, 2002.
128. I.I. Beilis R.L. Boxman, S. Goldsmith, "A hot refractory anode vacuum arc: Nonstationary plasma model", *IEEE Trans. Plasma Sci.* Vol. 29, pp. 690-694, 2001.
129. I.I. Beilis, S. Goldsmith, R.L. Boxman, "Interelectrode plasma evolution in a hot refractory anode vacuum arc: Theory and comparison with experiment", *Phys. Plasmas*, Vol. 9, pp. 3159-3170, 2002.
130. E. Gidalevich, S. Goldsmith and R. L. Boxman "Shock Discontinuity in High-Current Vacuum Arc", *IEEE Trans. Plasma Sci.* Vol. 29, pp. 700-703, 2001.
131. N. Parkansky, B. Alterkop, S. Goldsmith, R.L. Boxman, Z. Barkay. Thermal air oxidation of copper in an applied electric field. *Surface and Coating Technology* 146-147 (2001) 13.
132. E. Gidalevich, S. Goldsmith, and R. L. Boxman, "Shock front formation at vacuum arc anodes", *J. Appl. Physics*, Vol. 92, No. 9, pp. 4891 - 4896, 2002.

**RAYMOND LEON BOXMAN, Ph.D.**

133. E. Gidalevich, S. Goldsmith and R.L. Boxman, "Theoretical modelling of high pressure argon arc radiation" *Plasma Source Science and Technology*, Vol. 11, No. 4, pp. 513-519, 2002.
134. E. Gidalevich, S. Goldsmith and R.L. Boxman, "The role of the electrical polarization field in magnetic plasma confinement", *J. Phys. D: Appl. Phys.* Vol. 36, pp. 653-660, 2003.
135. B. Alterkop, N. Parkansky, S. Goldsmith, and R.L. Boxman, "Effect of air annealing on opto-electrical properties of amorphous tin oxide films", *J. Phys. D: Appl. Phys.* Vol. 36, pp. 552-558, 2003.
136. O. Zarchin, V.N. Zhitomirsky, S. Goldsmith, and R.L. Boxman, "Interaction of a vacuum arc plasma beam with an obstacle positioned normal to the plasma flow", *J. Phys. D: Appl. Phys.* Vol. 36, pp. 2262-8, 2003.
137. O. Zarchin, V.N. Zhitomirsky, R.L. Boxman, and S. Goldsmith, "Transport of a Vacuum-Arc Produced Plasma Beam in a Magnetized Cylindrical Duct", *IEEE Trans. Plasma Sci.* Vol. 31, pp. 977-982, 2003.
138. T. David, S. Goldsmith, and R.L. Boxman, "Electro-Optical and Structural Properties of Thin ZnO Films Prepared by Filtered Vacuum Arc Deposition" *Thin Solid Films*, 447-448C, pp. 61-67, 2003.
139. N. Parkansky, B. Alterkop, S. Goldsmith, and R.L. Boxman, "Effect of an applied voltage during annealing on the resistivity and transparency of the amorphous tin oxide films", *J. Vac. Sci. Technol.* Vol A21, pp. 1923-6, 2003.
140. I.I. Beilis, A. Shashurin, D. Arbilly, S. Goldsmith, and R.L. Boxman "Copper film deposition by a hot refractory anode vacuum arc", *Surface and Coating Technology* 177-178 (2004) pp. 233-7.
141. E. Gidalevich, R.L. Boxman, S. Goldsmith, "Hydrodynamic effects in liquids subjected to pulsed low current arc discharges", *J. Phys. D: Appl. Phys.* Vol. 36, pp. 1509-14, 2004.
142. V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, "Plasma distribution and SnO<sub>2</sub> coating deposition using a rectangular filtered vacuum arc plasma source", *Surface and Coating Technology* 185 (2004) pp. 1-11.
143. E. Gidalevich, S. Goldsmith, and R. L. Boxman, "Comparative characteristics of high-pressure arc radiation in argon, krypton and xenon atmospheres", *Plasma Source Sci. and Tech.* 13, No. 3, pp. 454-460, 2004.
144. N. Parkansky, R. L. Boxman, B. Alterkop, I. Zontag, Y. Lereah, Z. Barkay, "Single-Pulse Arc Production of Carbon Nanotubes in Ambient Air" *J. Phys. D: Appl. Phys.* Vol. 37, pp 2715-19, 2004.
145. V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, "Influence of the aperture diameter on plasma transport through the annular anode of a vacuum arc plasma deposition system", *Surface Coat. Technol.*, 188-189 (2004) pp. 220-227
146. I.I. Beilis, A. Shashurin, A. Nemirovsky, S. Goldsmith, R.L. Boxman, "Anode temperature distribution and coating characteristics in a Hot Refractory Anode Vacuum Arc with an asymmetric anode" *Surface and Coatings Technology* Vol. 188-189 (2004) pp. 228-233.
147. E. Gidalevich, S. Goldsmith, and R. L. Boxman, "Macroparticle rotation in the vacuum arc plasma jet", *J. Appl. Phys.* 95, No. 6, pp. 2969-2974, 2004.
148. N. Parkansky, B. Alterkop, R.L. Boxman, S. Goldsmith, Z. Barkay, Y. Lereah, "Pulsed discharge production of nano- and micro-particles in ethanol and their characterization" *Powder Technology* Vol. 150 (2005) pp. 36-41.
149. I.I. Beilis, A. Shashurin, A. Nemirovsky, R.L. Boxman, and S. Goldsmith "Imaging of the Anode Plasma Plume Development in a Hot Refractory Anode Vacuum Arc", *IEEE Trans. Plasma Sci.* Vol. 33, pp. 408-9, 2005.
150. T. David, S. Goldsmith and R.L. Boxman, "Dependence of zinc oxide thin film properties on filtered vacuum arc deposition parameters", *J. Phys. D: Appl. Phys.* 38 No 14 (21 July 2005) 2407-2416

**RAYMOND LEON BOXMAN, Ph.D.**

151. V.N. Zhitomirsky, T. David, R.L. Boxman, S. Goldsmith, A. Verdyan, Ya.M. Soifer, L. Rapoport, "Properties of SnO<sub>2</sub> coatings fabricated on polymer substrates using filtered vacuum arc deposition", *Thin Solid Films* 492 (2005) 187-194.
152. I. Beilis, A. Shashurin, R.L. Boxman and S. Goldsmith, "Influence of background gas pressure on copper film deposition and ion current in a hot refractory anode vacuum ARC" *Surface & Coatings Technology* 200 (5-6): 1395-1400 Nov. 21 2005
153. R. L. Boxman, I.I. Beilis, E. Gidalevich, and V. N. Zhitomirsky, "Magnetic control in vacuum arc deposition", *IEEE Trans. Plasma Sci.* 33, pp. 1618-1625, 2005.
154. I.I. Beilis, A. Shashurin, A. Nemirovsky, S. Goldsmith, and R.L. Boxman, "Measurements of the Anode Temperature in a Vacuum Arc With an Asymmetric Hot Refractory Mo Anode", *IEEE Trans. Plasma Sci.*, Vol.33, N5, Part 1I, 2005, (pp.1641-1647)
155. R.L. Boxman and V.N. Zhitomirsky, "Vacuum arc deposition devices", INVITED REVIEW PAPER *Rev. Sci. Inst* 77., 021101 (1-13), 2006.
156. E. Gidalevich and R. L. Boxman, "Sub- and supersonic expansion of an arc channel in liquid", *J. Phys. D: Appl. Phys.* 39 (2006) 652-659.
157. E. Cetinorgu, S. Goldsmith, and R.L. Boxman, "Air annealing effects on the optical properties of ZnO-SnO<sub>2</sub> thin films deposited by a filtered vacuum arc deposition system". *Semicond. Sci. Technol.* 21 (2006) 364-369.
158. N. Parkansky, O. Goldstein, B. Alterkop, R.L. Boxman, Z. Barkay, Yu. Rosenberg and G. Frenkel, "Features of micro and nano-particles produced by pulsed arc submerged in ethanol", *Powder Technology* 161 (3): 215-219 Feb. 3, 2006
159. N. Parkansky, G. Frenkel, B. Alterkop, R.L. Boxman, S. Goldsmith, Z. Barkay, Yu. Rosenberg and O. Goldstein, "Influence of pulsed arc parameters on powder production in ethanol", *Powder Technology* 162 (2): 121-125 Mar 1, 2006.
160. I.I. Beilis, A. Shashurin, R.L. Boxman, and S. Goldsmith, "Total ion current fraction in a hot refractory anode vacuum arc", *Appl. Phys. Lett.* 88 (7): Art. No. 071501 Feb. 13 2006.
161. V.N. Zhitomirsky, E. Cetinorgu, E. Adler, Yu. Rosenberg, R.L. Boxman and S. Goldsmith, "Filtered Vacuum Arc Deposition of Transparent Conducting Al-doped ZnO Films", *Thin Solid Films*, 513 (2006), pp. 885-890.
162. B. Alterkop, S. Goldsmith and R. L. Boxman "Drift wave instability in the presheath of a fully ionized collisional plasma" *Plasma Sources Sci. Technol.* **15** 670-675, 2006.
163. E. Gidalevich, R. L. Boxman, "Steady-state model of an arc discharge in flowing water", *Plasma Source Sci. Tech.* **15**, pp. 765-772, 2006
164. B. Alterkop and R.L. Boxman, "Sagdeev Potential and Sheath Criterion for a Multi-Component", *Contrib. Plasma Phys.* 46, No. 10, 826 - 833 (2006) / DOI 10.1002/ctpp.200610083.
165. E. Çetinörgü, S. Goldsmith, Z. Barkay, and R.L. Boxman "The dependence of filtered vacuum arc deposited ZnO-SnO<sub>2</sub> thin films characteristics on substrate temperature", *J. Phys. D: Appl. Phys.* 39 (2006) 5245-5251.
166. A. Moshkovith, V. Perfiliev, D. Gindin, N. Parkansky, R. Boxmanb, L. Rapoport, "Surface texturing using pulsed air arc treatment" *Wear* (2007) doi:10.1016/j.wear.2006.11.043
167. A. Shashurin, I.I. Beilis, Y. Sivan, S. Goldsmith and R.L. Boxman, "Copper film deposition rates by a hot refractory anode vacuum arc and magnetically filtered vacuum arc" *Surface and Coatings Technology*, 201, N7, 2006, (p.4145-4151).
168. E.D. Bender, V.N. Zhitomirsky, R.L. Boxman, "Hall stratum filtered cathodic arc source for carbon plasma", *Surface & Coatings Technology* 201 (2007), pp. 6095-6100.
169. E. Çetinörgü, S. Goldsmith, and R.L. Boxman, "The effect of substrate temperature on filtered vacuum arc deposited zinc oxide and tin oxide thin films", *J. Crystal Growth* 209 (2007) pp. 259-267.

### Conference Papers

1. R.L. Boxman, "Magnetic Constriction Effects Prior to Anode Spot Formation in Vacuum Arcs," IIIrd International Conference of Electrode Phenomena in Gas Discharge, Lisbon, 1976.
2. R.L. Boxman and S. Goldsmith, "Ion and Neutral Excited State Densities in a Multi-Cathode-Spot Vacuum Arc," 30th Gaseous Electronics Conference, Palo Alto, 1977, Bull. Am. Phys. Soc., Vol. 23, p. 138, 1978.
3. S. Shalev, S. Goldsmith, and R.L. Boxman, "Density of Cd I and Cd II Excited States in a Multi-Cathode-Spot Vacuum Arc, Part I - Spatial Dependence," 1980 Meeting of the Israel Physical Society, Rehovoth, Israel, Bull. IPS Vol. 26, p. 35, 1980.
4. S. Shalev, S. Goldsmith and R.L. Boxman, "Density of Cd I and Cd II Excited States in a Multi-Cathode-Spot Vacuum Arc, Part II - Temporal Dependence," 1980 Meeting of the Israel Physical Society, Rehovoth, Israel, Bull. IPS Vol. 26, p. 36, 1980.
5. S. Goldsmith, S. Shalev, and R.L. Boxman, "Population Inversion of Cd II Levels in a Multi-Cathode-Spot Vacuum Arc," 1980 IEEE Int. Conf. on Plasma Science, (paper 4D5), Madison, WI, 1980.
6. S. Shalev, S. Goldsmith, and R.L. Boxman, "Density of Cd I and Cd II Excited States in a Multi-Cathode-Spot Vacuum Arc," IXth International Symposium on Discharges and Electrical Insulation in Vacuum, Eindhoven, The Netherlands, September, 1980. Nederlands Tijdschrift voor Vacuumtechniek, Vol. 18e, pp. 69-73, 1980.
7. R.L. Boxman and S. Goldsmith, "Energy and Mass Transport in the Interelectrode Plasma of a Multi-Cathode-Spot Vacuum (Metal Vapor) Arc", International Workshop on Plasma Chemistry in Technology, Ashkelon, Israel, 1981, p. 34.
8. Y. Bressler, R.L. Boxman, and S. Goldsmith, "Density Population of ZnI, ZnII, and ZnIII Excited States in a Multi-Cathode-Spot Vacuum Arc", 1981 Meeting of the Israel Physical Society, Tel-Aviv, Israel, Bull. IPS. Vol. 27, p. 72, 1981.
9. S. Goldsmith, Y. Bressler and R.L. Boxman, "Density Populations of ZnI, ZnII Excited States in Multi-Cathode-Spot Vacuum Arcs", 34th Gaseous Electronics Conference, Boston, 1981, p.70.
10. R.L. Boxman and S. Goldsmith, "The Anode Region in a Uniform Multi- Cathode-Spot Vacuum Arc", 34th Gaseous Electronics Conference, Boston, 1981, p.72.
11. I. Izraeli, R.L. Boxman and S. Goldsmith, "The Influence of the Self Magnetic Field on the Current Flow in Axi-symmetric Tensor Conductivity Plasma", 34th Gaseous Electronics Conference, Boston, 1981, p.83.
12. S. Shalev, S. Goldsmith and R.L. Boxman, "Anodic Erosion in Multi Cathode-Spot Vacuum Arcs", 35th Gaseous Electronics Conference, Dallas, 1982.
13. S. Shalev, S. Goldsmith and R.L. Boxman, "In-situ Determination of Macroparticles Velocity Distributions in a Multi-Cathode-Spot Copper Vacuum Arc", Xth International Symposium on Discharges and Electrical Insulation in Vacuum, Columbia, S.C., 1982, pp. 174-180.
14. I. Izraeli, S. Goldsmith and R.L. Boxman, "The Influence of the Self Magnetic Field on the Steady State Current Distribution in an Axially Flowing Conducting Medium", Xth International Symposium on Discharges and Electrical Insulation in Vacuum, Columbia, S.C., 1982, pp. 193-199.
15. S. Goldsmith, S. Shalev and R.L. Boxman, "Melting of the Anode in a Multi-Cathode-Spot Vacuum Arc", Xth International Symposium of Discharges and Electrical Insulation in Vacuum, Columbia, S.C., 1982, pp. 148-154.
16. F.T. Warren, R.L. Boxman, J.E. Thompson and T.S. Sudarshan, "Current Evolution in a Pulsed Overstressed Radial Vacuum Gap", Xth International Symposium on Discharges and Electrical Insulation in Vacuum, Columbia, S.C., 1982, pp. 43-53.

**RAYMOND LEON BOXMAN, Ph.D.**

17. J.M. Wilson, R.L. Boxman and J.E. Thompson, "Breakdown Time of a Triggered Vacuum and Low-Pressure Switch", Xth International Symposium on Discharges and Electrical Insulation in Vacuum, Columbia, S.C., 1982, pp. 268-272.
18. R. Lee, T.S. Sudarshan, J.E. Thompson and R.L. Boxman, "Predischage Current Measurements in Vacuum Gaps Bridged with Plexiglass Insulators", Xth International Symposium on Discharges and Electrical Insulation in Vacuum, Columbia, S.C., 1982, pp. 288-297.
19. R.L. Boxman, S. Goldsmith, I. Izraeli and S. Shalev, "A Model of the Multi-Cathode-Spot Vacuum Arc", Xth International Symposium on Discharges and Electrical Insulation in Vacuum, Columbia, S.C., 1982, pp. 161-172. *INVITED PAPER.*
20. R.L. Boxman, S. Goldsmith, S. Shalev, H. Yaloz, and N. Brosh "Fast Deposition of Metallurgical Coatings and Production of Surface Alloys Using a Pulsed High Current Vacuum Arc", XIth International Symposium on Discharges and Electrical Insulation in Vacuum, Berlin, September, 1984, pp. 471-474.
21. I. Izraeli, A.W. Whitman, R.L. Boxman and S. Goldsmith, "Asymptotic Analysis of the Steady State Current Flow in a Uniform Multi-Cathode-Spot Generated Vacuum Arc Plasma Flow", XIth International Symposium on Discharges and Electrical Insulation in Vacuum, Berlin, September, 1984, pp. 463-465.
22. S. Shalev, R.L. Boxman and S. Goldsmith, "Macroparticle Dynamics During MCS Vacuum Arcs", XIth International Symposium on Discharges and Electrical Insulation in Vacuum, Berlin, September, 1984, pp. 459-462.
23. S. Shalev, R.L. Boxman and S. Goldsmith, "Spectroscopic Investigation of Anode Erosion During Multi-Cathode-Spot Vacuum Arcs", XIth International Symposium on Discharges and Electrical Insulation in Vacuum, Berlin, DDR, September, 1984, pp. 4-470.
24. B. Gellert, E. Schade and R.L. Boxman, "Time and Spatially Resolved Spectroscopy of the Plasma State Prior to and During Anode Spot Formation in High Current Vacuum Arcs", XIth International Symposium on Discharges and Electrical Insulation in Vacuum, Berlin, DDR, September, 1984, pp. 139-142.
25. R.L. Boxman, S. Goldsmith, S. Shalev, H. Yaloz and N. Brosh, "Fast Deposition of Metallurgical Coatings and Production of Surface Alloys Using a Pulsed High Current Vacuum Arc", *INTERFINISH 84*, 11th World Congress on Metal Finishing, Jerusalem, October, 1984, pp. 161-167. *Awarded Boris and Renee Joffe Prize for Best Paper Presented.*
26. R.L. Boxman, "Vacuum Arc Deposition", Israel Vacuum Society Symposium on Deposition Techniques, Tel-Aviv, January, 1984. *INVITED LECTURE.*
27. R.L. Boxman, I. Izraeli, S. Goldsmith, "A Review of Processes Occurring at the Anode in the Multi-Cathode-Spot Vacuum Arc and Some Thoughts on Anode Spot Formation", VIth Workshop on Electrode Phenomena, Bod Honnef, FRG, September, 1984. *INVITED LECTURE.*
28. B. Gellert, E. Schade and R.L. Boxman, "Time and Spatially Resolved Spectroscopy of the Plasma State Prior to and During Anode Spot Formation in High Current Vacuum Arcs", VIth Workshop on Electrode Phenomena, Bod Honnef, FRG, September, 1984.
29. R.L. Boxman, S. Goldsmith, E. Sapir, "Metallographic Measurement of Heat Flux at the Anode Surface of a Vacuum Arc". Guest Lecture, Current Zero Club, Ludvika, Sweden, September, 1985.
30. G. Disatnik, R.L. Boxman, S. Goldsmith, "Characteristics of macro particle emission from a high current density multi-cathode-spot pulsed vacuum arc", XIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Shores, Israel, 22-25 September, 1986, pp. 104-108.
31. S. Goldsmith, R.L. Boxman, E. Sapir, Y. Cohen, H. Yaloz, N. Brosh, "Distribution of peak temperature and energy flux on the surface of the anode in a multi-cathode-spot pulsed vacuum arc", XIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Shores, Israel, 22-25 September, 1986, pp. 114-119.

**RAYMOND LEON BOXMAN, Ph.D.**

32. I. Izraeli, R.L. Boxman, S. Goldsmith, "The current distribution and the magnetic pressure profile in a vacuum arc subjected to an axial magnetic field", XIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Shores, Israel, 22-25 September, 1986, pp. 125-130.
33. S. Bababeygy, R.L. Boxman, S. Goldsmith, "Corrosion evaluation of very rapid high-current vacuum arc coatings", XIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Shores, Israel, 22-25 September, 1986, pp. 178-182.
34. R.L. Boxman, "Fundamentals of switching in vacuum", XIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Shores, Israel, 22-25 September, 1986, workshop on Switching in Vacuum.
35. R.L. Boxman and S. Goldsmith, "Cathode-spot arc coatings: physics, deposition and heating rates, and some examples", International Conference on Metallurgical Coatings, San Diego, March, 1987, p. 82. *INVITED LECTURE*.
36. S. Bababeygy, R.L. Boxman, and S. Goldsmith, "Corrosion protection by vacuum arc coatings", INTERFINISH-88, XIIth World Congress on Metal Finishing, Paris, October, 1988. Galvano-Organic-Treatments De Surface No. 588, p. 635, 1988.
37. Y. Cohen, R.L. Boxman, and S. Goldsmith, "Angular distribution of ion current emerging from an aperture anode in a vacuum arc", XIIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Paris, June, 1988, pp. 300-302.
38. R.L. Boxman and S. Goldsmith, "Principles and applications of vacuum arc coatings", XIIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Paris, June, 1988, pp. 281-286. *INVITED LECTURE*.
39. R.L. Boxman and S. Goldsmith, "A model for a uniform steady-state vacuum arc with a hot anode", XIIIth International Symposium on Discharges and Electrical Insulation in Vacuum, Paris, June, 1988, pp. 190-192.
40. S. Bababeygy, R.L. Boxman and S. Goldsmith, "Anodic polarization and corrosion protection of vacuum arc coatings", Metal Finishing Society of Israel annual meeting, Eilat, March, 1988.
41. R.L. Boxman and S. Goldsmith, "Characterization of a 1 kA vacuum arc plasma gun for use as a metal vapor deposition source", 8th Int. Conf. on Thin Films/17th Int. Conf. on Metallurgical Coatings, San Diego, 1990, p. A-126.
42. R.L. Boxman and S. Goldsmith, "Vacuum arc deposition in the 19th Century", XIVth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Santa Fe, Sept., 1990, p. 176. *INVITED PAPER*.
43. U. Kinrot, S. Goldsmith and R.L. Boxman, "Spectroscopic study of the spatial distribution of helium background gas in an aluminum vacuum arc", XIVth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Santa Fe, Sept., 1990, pp. 155-159. *INVITED PAPER*.
44. U. Kinrot, S. Goldsmith and R.L. Boxman, "Space resolved spectroscopic study of aluminum vacuum arc burning in helium background", XIVth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Santa Fe, Sept., 1990, pp. 150-154. *INVITED PAPER*.
45. R.L. Boxman and S. Goldsmith, "Macroparticle Contamination in Cathodic Arc Coatings: Generation, Transport, and Control", International Conference on Metallurgical Coatings and Thin Films, San Diego, April, 1991. *INVITED PAPER*.
46. A. Ishaaya, R.L. Boxman and S. Goldsmith "Measurement of cathode spot velocity and distribution on a disc cathode in a radial magnetic field", presented at the Int. Conf. on Metallurgical Coatings and Thin Films, San Diego, April, 1992.
47. N. Parkansky, I. Beilis, R.L. Boxman, and S. Goldsmith, "Electrode Erosion During Pulsed Arcing", to be presented at XVth Int. Symp. On Discharges And Electrical Insulation In Vacuum, Darmstadt, September, 1992, pp. 490-493.
48. A. Ben-Shalom, R.L. Boxman and S. Goldsmith, "Ion current collected at various distances and argon background pressures in a copper vacuum arc", XVth Int. Symp. On Discharges And Electrical Insulation In Vacuum, Darmstadt, September, 1992, pp. 301-305.

**RAYMOND LEON BOXMAN, Ph.D.**

49. A. Vaknin, S. Goldsmith and R.L. Boxman, "Spectroscopic study of electron density in a copper vacuum arc", XVth Int. Symp. On Discharges And Electrical Insulation In Vacuum, Darmstadt, September, 1992, pp. 382-386.
50. N. Parkansky, R.L. Boxman and S. Goldsmith, "Development and application of pulsed air arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films, San Diego, April, 1993.
51. R.L. Boxman and S. Goldsmith, "Mass and surface conductivity gain on polymer surfaces metalized using vacuum arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films, San Diego, April, 1993.
52. A. Ben-Shalom, R.L. Boxman and S. Goldsmith, "SnO<sub>2</sub> transparent conductor films produced by a filtered vacuum arc", Int. Conf. on Metallurgical Coatings and Thin Films, San Diego, April, 1993.
53. I. Beilis, R.L. Boxman, M. Keidar and S. Goldsmith, "The kinetics of macroparticles charging in strongly ionized plasmas", Israel Physical Society, 1993 Annual Meeting. Bull. IPS Vol. 39, p. 79, 1993.
54. A. Ben-Shalom, L. Kaplan, R.L. Boxman, S. Goldsmith, M. Nathan, "Vacuum arc deposition of conductive transparent Sn-O films, and the influence of post-deposition annealing on their phase composition, resistance and transparency", 13th Israeli Vacuum Society Conference, Tel-Aviv, May, 1993, p. 16.
55. S. Goldsmith, H. Rosenthal, P. Avivi and R.L. Boxman, "Diamond growth in hot anode vacuum arcs", Diamond Films 93, Albufeira, Portugal, 20-24 September, 1993.
56. M. Keidar, I. Beilis, S. Goldsmith and R.L. Boxman, "The kinetics of macroparticles charging in strongly ionized plasmas", Int. Conf. on Phenomena in Ionized Gases, Bochum, September, 1993. pp. 237-8.
57. A. Ben-Shalom, R.L. Boxman and S. Goldsmith, "Vacuum arc deposition of transparent windshield defroster coatings", SAE Subzero Engineering Conditions Conference, Brainerd, MN (USA) 21-25 Feb., 1994.
58. V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, "Influence of an external magnetic fields on cathode spot motion and coating deposition using filtered arc evaporation", Int. Conf. on Metallurgical Coatings and Thin Films - ICMCTF-94, San Diego, April, 1994.
59. L. Kaplan, A. Ben-Shalom, R.L. Boxman, S. Goldsmith, M. Nathan, "Sn-O based transparent conductive films produced by filtered vacuum arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films - ICMCTF-94, San Diego, April, 1994.
60. D. Arbilly, R.L. Boxman and S. Goldsmith, "Amorphous Si thin films prepared by vacuum arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films - ICMCTF-94, San Diego, April, 1994.
61. N. Parkansky, Yu. Rosenberg, R. Boxman and S. Goldsmith, "Pulsed air arc deposition of amorphous coatings using Fe-Mo powder mixtures", Int. Conf. on Metallurgical Coatings and Thin Films - ICMCTF-94, San Diego, April, 1994.
62. B. Alterkop, I. Beilis, R. Boxman and S. Goldsmith, "Influence of current instabilities on the parameters of the vacuum arc plasma jet", Int. Symp. on Discharges and Electrical Insulation in Vacuum, Moscow, May, 1994.
63. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "Non-stationary macroparticle charging in an arc plasma jet", Int. Symp. on Discharges and Electrical Insulation in Vacuum, Moscow, May, 1994.
64. H. Rosenthal, I. Beilis, R.L. Boxman and S. Goldsmith, "Investigation of the non-stationary anode temperature in a hot anode vacuum arc", Int. Symp. on Discharges and Electrical Insulation in Vacuum, Moscow, May, 1994.
65. E. Gidalevich, S. Goldsmith and R.L. Boxman, "Vacuum Arc Plasma Beam Motion in a Curved Magnetic Field", Proc. Int. Symp. on Discharges and Electrical Insulation in Vacuum, pp.122-127, Moscow, May, 1994.



**RAYMOND LEON BOXMAN, Ph.D.**

66. V.N. Zhitomirsky, R.L. Boxman and S. Goldsmith, "Plasma and coating characteristics in a filtered vacuum arc deposition system", Int. Symp. on Discharges and Electrical Insulation in Vacuum, Moscow, May, 1994.
67. R.L. Boxman, S. Goldsmith, A. Ben-Shalom, L. Kaplan, D. Arbilly, E. Gidalevich, V. N. Zhitomirsky, A. Ishaya, M. Keidar, I. Beilis, "Filtered vacuum arc deposition of semi-conductor thin films", Int. Symp. on Discharges and Electrical Insulation in Vacuum, Moscow, May, 1994. *INVITED LECTURE*.
68. N. Parkansky, R.L. Boxman, S. Goldsmith, Y. Rosenberg, A. Ben-Shalom, L. Kaplan, D. Arbilly, "Improvement of thin film semi-conductor conductivities using a transverse current during deposition, Int. Conference on Metallurgical Coatings and Thin Films, ICMCTF-94, San-Diego, April, 1994.
69. K. Pourrezaei, R.B. Beard, I. Shevets, M. Delaurentis, R.L. Boxman, N. Croitoru, "Development of antiinfection and antithrombosis coatings for inside and outside of medical catheters", Int. Conference on Metallurgical Coatings and Thin Films, ICMCTF-94, San-Diego, April 25-29, 1994.
70. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "Electrostatic field effects on the transport of macroparticles in magnetized plasma ducts", ISPC-12, pp. 1367-1372. Minneapolis, 1995.
71. L. Kaplan, V.N. Zhitomirsky, R.L. Boxman and S. Goldsmith, "Arc behavior during filtered vacuum arc deposition of Sn-O thin films", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-95, San Diego, April, 1995.
72. V.N. Zhitomirsky, L. Kaplan, R.L. Boxman and S. Goldsmith, "Ion current distribution in the plasma duct of a filtered vacuum arc deposition system", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-95, San Diego, April, 1995.
73. N. Parkansky, R. Rosenbaum, Y. Rosenberg, R.L. Boxman and S. Goldsmith, "Influence of transverse current during In-O vapor deposition", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-95, San Diego, April, 1995.
74. N. Parkansky, R.L. Boxman, S. Goldsmith and Y. Rosenberg, "Corrosion resistance of Zn-coatings produced by pulsed-air arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-95, San Diego, April, 1995.
75. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "The magnetic presheath in the plasma-wall transition", ICPIG XXII, Vol. II, pp. 157-158. Hoboken, NJ, July, 1995.
76. M. Keidar, I. Beilis, R.L. Boxman, S. Goldsmith, "Vacuum arc plasma jet parameter distribution in the interelectrode gap in a magnetic field", Israel Physical Society Meeting, Jerusalem, 1996, Bull. IPS, Vol. 42, p.182.
77. R.L. Boxman, S. Goldsmith, V. Zhitomirsky, E. Gidalevich, I. Beilis, M. Keidar, "Filtered vacuum arc deposition", Israel Physical Society Meeting, Jerusalem, 1996, Bull. IPS, Vol. 42, p. 168.
78. R.L. Boxman, S. Goldsmith, V.N. Zhitomirsky, B. Alterkop, E. Gidalevich, I. Beilis and M. Keidar, "Recent progress in filtered vacuum arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-96, San Diego, April, 1996. *INVITED PAPER*.
79. B. Alterkop, N. Parkansky, R.L. Boxman and S. Goldsmith, "Influence of a parallel electric field on the conductivity of a growing indium oxide film", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-96, San Diego, April, 1996.
80. N. Parkansky, B. Alterkop, R. Rosenbaum, R.L. Boxman and S. Goldsmith, "Reduction and oxidation of amorphous indium oxide films during post-deposition transverse current injection", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-96, San Diego, April, 1996.
81. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "Macroparticle interaction with a substrate in cathodic vacuum arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-96, San Diego, April, 1996.



**RAYMOND LEON BOXMAN, Ph.D.**

82. V.N. Zhitomirsky, U. Kinrot, B. Alterkop, R.L. Boxman and S. Goldsmith, "Influence of gas pressure on the ion current distribution in a filtered vacuum arc deposition system", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-96, San Diego, April, 1996.
83. L. Kaplan, I. Rusman, R.L. Boxman, S. Goldsmith, M. Nathan, and E. Ben-Jacob, "STM and XPS Study of Filtered Vacuum Arc Deposited Sn-O Films After Rapid Thermal Annealing", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-96, San Diego, April, 1996.
84. B. Alterkop, V.N. Zhitomirsky, S. Goldsmith, R.L. Boxman, "Vacuum arc plasma beam transport through a toroidal duct", Proc. XVIIth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Berkeley, July, 1996, pp. 922-926.
85. B. Alterkop, E. Gidalevich, S. Goldsmith and R.L. Boxman, "Numerical study of plasma beam propagation in a toroidal duct", Proc. XVIIth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Berkeley, July, 1996, pp. 853-857.
86. B. Alterkop, E. Gidalevich, S. Goldsmith and R.L. Boxman, "Motion of a magnetized vacuum arc plasma beam in a quarter-torus filter", Proc. XVIIth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Berkeley, July, 1996, pp. 848-852.
87. V.N. Zhitomirsky, B. Alterkop, U. Kinrot, R.L. Boxman and S. Goldsmith, "Role of the magnetic field in the cathode region in cathodic vacuum arc operation", "Proc. XVIIth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Berkeley, California, USA, July 21-26, 1996, Vol. 2, pp. 876-880.
88. V.N. Zhitomirsky, R.L. Boxman and S. Goldsmith, "Ion current distribution within a toroidal duct of a filtered vacuum arc deposition system", "Proc. XVIIth Int. Symp. on Discharges and Electrical Insulation in Vacuum," Berkeley, California, USA, July 21-26, 1996, Vol. 2, pp. 927-931.
89. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "Potential and current distribution in the interelectrode gap of the vacuum arc in a magnetic field", Proc. XVIIth Int. Symp. on Discharges and Electrical Insulation in Vacuum, Berkeley, July, 1996, pp. 146-145.
90. M. Keidar, I. Beilis, R.L. Boxman and S. Goldsmith, "The free MHD flow of the low-density vacuum arc cathodic jet", 8th Beer Sheva International Seminar MHD Flows and Turbulence, Jerusalem, February, 1996, p. 9.
91. I. Grimberg, V.N. Zhitomirsky, N. Parkansky, A. Matthews, A. Wilson, R.L. Boxman, B.Z. Weiss, and S. Goldsmith, "Structure and Tribological Properties of Thin Vacuum Arc Coatings on Polysulfone", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-97, San-Diego, USA, April 1997.
92. V.N. Zhitomirsky, I. Grimberg, R.L. Boxman, B.Z. Weiss, N.A. Travitzky and S. Goldsmith, "Vacuum Arc Deposition and Microstructure of ZrN-Based Coatings", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-97, San-Diego, USA, April 1997.
93. I. I. Beilis, R.L.Boxman, S. Goldsmith, The Plasma-Model of New Mode Hot Anode Vacuum Arc, XXIII ICPIG, Toulouse, France, July 1997, Vol. II, pp. 84-85.
94. R.L. Boxman "Vacuum Arc Deposof Multi-layer and Multi-component Coatings", American Physical Society - Plasma Physics Division Conference, Pittsburgh, PA, USA, Nov. 1997. *INVITED LECTURE*
95. I. I. Beilis, R.L. Boxman, S. Goldsmith, The Plasma-Model of New Mode Hot Anode Vacuum Arc, XXIII ICPIG, Toulouse, France, July 1997, Vol. II, pp. 84-85.
96. S. G. Wang, R.L. Boxman and S. Goldsmith, "Measurement of the Ion Current in a Variable Gap Filtered Vacuum Arc Carbon Source" 1<sup>st</sup> Israeli Conference on Plasma Physics and its Applications, Tel Aviv, Feb. 1998.
97. E. Gidalevich, R.L. Boxman, and S. Goldsmith, "Shock Front Formation in Plasma Coating Devices", 1<sup>st</sup> Israeli Conference on Plasma Physics and its Applications, Tel Aviv, Feb. 1998.
98. N. Narkiss, J.Ashkenazy, G. Appelbaum, Y. Raitses, R. Boxman, "Arc Discharge Hollow Cathodes for Space Propulsion Applications", 1<sup>st</sup> Israeli Conference on Plasma Physics and its Applications, Tel Aviv, Feb. 1998.

**RAYMOND LEON BOXMAN, Ph.D.**

99. R. Ben-Ami, V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, "Plasma Distribution in a Triple Cathode Vacuum Arc Deposition Apparatus", 1<sup>st</sup> Israeli Conference on Plasma Physics and its Applications, Tel Aviv, Feb. 1998.
100. R.L. Boxman, N. Parkansky, S. Goldsmith, "Pulsed Arc Deposition", 1<sup>st</sup> Int. Pulsed Plasma Surface Technologies Workshop, San Diego, April 1998.
101. I. Grimberg, V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, and B.Z. Weiss, "Multicomponent Ti-Zr-N and Ti-Nb-N coatings deposited by vacuum arc", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-98, San-Diego, USA, 1998.
102. V.N. Zhitomirsky, I. Grimberg, R.L. Boxman, S. Goldsmith, M.C. Joseph, B.Z. Weiss, and A. Matthews, "Structure and Properties of Vacuum Arc TiN/NbN Multilayer Coatings", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-98, San-Diego, USA, 1998.
103. V.N. Zhitomirsky, I. Grimberg, M.C. Joseph, R.L. Boxman, B.Z. Weiss, A. Matthews, and S. Goldsmith, "Vacuum Arc Deposition of Metal/Ceramic Coatings on Polymer Substrates", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-98, San-Diego, USA, 1998.
104. N. Parkansky, B. Alterkop, R.L. Boxman, S. Goldsmith, Yu. Rosenberg "The effect of transverse current injection on the structural and electrical properties of Ti films during annealing in air", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-98, San-Diego, USA, 1998.
105. I. Beilis, M. Keidar, R.L. Boxman, S. Goldsmith, "Effects of Macroparticle Separation in Positively Biased Ducts in the Filtered Vacuum Arc Deposition System", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-98, San-Diego, USA, 1998.
106. D. Arbilly, R. Nadis, I. Balberg, R.L. Boxman, S. Goldsmith, "Opto-electronic Properties of Amorphous Silicon Films Rapidly Grown by Filtered Vacuum Arc", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-98, San-Diego, USA, 1998.
107. N. Parkansky, I.I. Beilis, R. L. Boxman, S. Goldsmith and Yu. Rosenberg, "Anode mass loss during pulsed air arc deposition", Int. Conf. on Metallurgical Coatings and Thin Films, ICMCTF-98, San Diego, USA, 1998.
108. V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, I. Grimberg, and B.Z. Weiss, "Superposition of two plasma beams produced by different cathodes in a triple-cathode vacuum arc deposition apparatus", XVIIIth Int. Symposium on Discharges and Electrical Insulation in Vacuum, Eindhoven, the Netherlands, 1998.
109. I.I. Beilis, M. Keidar, R.L. Boxman, and S. Goldsmith, "Plasma expansion and current flow in a vacuum arc with a small anode", Proc. XVIIIth Int. Symposium on Discharges and Electrical Insulation in Vacuum, Eindhoven, the Netherlands, pp.232-235, 1998.
110. I. I. Beilis, R.L. Boxman, S. Goldsmith, "A vacuum arc with refractory hot anode" Proc. XVIIIth Int. Symposium on Discharges and Electrical Insulation in Vacuum, Eindhoven, the Netherlands, August 17-21, 1998 (pp.240-243).
111. I. I. Beilis, "A cathode spot vacuum arc with graphite cathode" Proc. XVIIIth Int. Symposium on Discharges and Electrical Insulation in Vacuum, Eindhoven, the Netherlands, Eindhoven, August 17-21, 1998 (pp.236-239).
112. E. Gidalevich, R.L. Boxman, S. Goldsmith, "Mixing of supersonic plasma jets", XVIIIth Int. Symposium on Discharges and Electrical Insulation in Vacuum, Eindhoven, the Netherlands, 17-21 August 1998. *INVITED LECTURE*
113. E. Gidalevich, R.L. Boxman, S. Goldsmith, "A Simple Method of Enhancing Magnetic Filter Efficiency", Proc. Int. Symp. on Discharges and Electrical Insulation in Vacuum, Eindhoven, The Netherlands, Vol. 2, pp. 581-584, 1998.
114. I. V.N. Zhitomirsky, I. Grimberg, L. Rapoport, N.A. Travitzky, R.L. Boxman, S. Goldsmith and B.Z. Weiss, "Vacuum arc deposition of TiN, NbN and TiN/NbN multilayer coatings", Proc. Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-99, San-Diego, USA, 12-16 April 1999.

**RAYMOND LEON BOXMAN, Ph.D.**

115. V.N. Zhitomirsky, I. Grimberg, M.C. Joseph, R.L. Boxman, A. Matthews and B.Z. Weiss, "Vacuum arc deposition of conductive wear resistant coatings on polymer substrates", Proc. Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-99, San-Diego, USA, 12-16 April 1999.
116. N. Parkansky, B. Alterkop, S. Goldsmith, R.L. Boxman, "The effect of an electric field on the high temperature oxidation of copper in air", Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-99, San-Diego, USA, 12-16 April 1999.
117. R.L. Boxman, S. Goldsmith, V. Zhitomirsky, B.-Z. Weiss, I. Grimberg, and L. Rapoport, "Deposition of multi-layer and multi-component hard coatings using a multi-cathode vacuum arc deposition system", European Material Conference (E-MRS 1999 Spring Meeting), Strasbourg, 1-4 June 1999, p. B-13. *INVITED LECTURE*.
118. V.N. Zhitomirsky, I. Grimberg, L. Rapoport, R.L. Boxman, S. Goldsmith, B.Z. Weiss, "Bias Voltage Effect on the Structure and Properties of Vacuum Arc Deposited TiN Coatings", Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-2000, San-Diego, USA, 10-14 April 2000.
119. I.I. Beilis, R.L. Boxman, S. Goldsmith, "The Hot Refractory Anode Vacuum Arc – A New Plasma Source for Metallic Film Deposition", Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-2000, San-Diego, USA, 10-14 April 2000.
120. N. Parkansky, V.N. Zhitomirsky, B. Alterkop, S. Goldsmith, R.L. Boxman, Y. Rosenberg, and Z. Barkay, "Effect of Transverse Current Injection During Vacuum Arc Deposition of TiN", Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-2000, San-Diego, USA, 10-14 April 2000.
121. N. Parkansky, B. Alterkop, S. Goldsmith, R.L. Boxman, H. Wulff, M. Quaas, A. Quade, "Electric Field Nano-organization of Thin Titanium Films During Vacuum Arc Deposition", Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-2000, San-Diego, USA, 10-14 April 2000.
122. R.L. Boxman, " Vacuum Arc Deposition: Early History and Recent Developments ", *INVITED DYKE AWARD LECTURE*, XIX<sup>th</sup> Int. Symposium on Discharges and Electrical Insulation in Vacuum, Xi'an, September 2000, pp. 1-8.
123. I.I. Beilis, R.L. Boxman, and S. Goldsmith, "A Non-stationary Model for Vacuum Arcs with a Refractory Hot Anode", XIX<sup>th</sup> Int. Symposium on Discharges and Electrical Insulation in Vacuum, Xi'an, September 2000, pp. 226-230.
124. E. Gidalevich, S. Goldsmith, and R.L. Boxman, "An Upper Limit for the Electric Current for Shock-free Plasma Flow in a Vacuum Arc", XIX<sup>th</sup> Int. Symposium on Discharges and Electrical Insulation in Vacuum, Xi'an, September 2000, pp. 268-272.
125. V.N. Zhitomirsky, O. Zarchin, S.G. Wang, R.L. Boxman, and S. Goldsmith, "Ion Current Distribution Produced by a Vacuum Arc Carbon Plasma Source", XIX<sup>th</sup> Int. Symposium on Discharges and Electrical Insulation in Vacuum, Xi'an, September 2000, pp. 654-657.
126. V.N. Zhitomirsky, O. Zarchin, R.L. Boxman and S. Goldsmith, "Properties of coatings deposited using a filtered vacuum arc carbon plasma source" Israel-Japan Binational Workshop on Diamond Science and Technology, Tosayamada (Japan), December 2001.
127. R.L. Boxman, "Vacuum Arc Deposition of Coatings and Thin Films", Society for the Advancement of Material and Process Engineering – 9<sup>th</sup> Israeli Technical Conference, Herzliya, Israel, January 2002. *invited lecture*.
128. I.I. Beilis, A. Nemirovsky, S. Goldsmith, and R.L. Boxman, "Two dimensional thermal model of a refractory anode in a vacuum arc", XX<sup>th</sup> Int. Symposium on Discharges and Electrical Insulation in Vacuum, Tours, July 2002, pp. 279-282.
129. V.N. Zhitomirsky, O. Zarchin, R.L. Boxman, and S. Goldsmith, "Transport of a vacuum arc produced plasma beam in a magnetized cylindrical duct", XX<sup>th</sup> Int. Symposium on Discharges and Electrical Insulation in Vacuum, Tours, July 2002, pp. 670-673.

**RAYMOND LEON BOXMAN, Ph.D.**

130. N. Parkansky, R.L. Boxman, S. Goldsmith, B. Alterkop, Y. Lereah, Z. Barkay, "Carbon Nanotube Production during Short Arc Pulses in Air" 21<sup>st</sup> Israel Vacuum Society General Conference, 11-12 September 2002, Tel Aviv.
131. R.L. Boxman, V. Zhitomirsky, S. Goldsmith, T. David "Deposition of SnO<sub>2</sub> Coatings using a Rectangular Filtered Vacuum Arc Source", The 6<sup>th</sup> Israeli Conference on Plasma Science and Applications, 12 Feb 2003, Holon.
132. N. Parkansky, R.L. Boxman, B. Alterkop, Y. Lereah, and Z. Barkay, "Synthesis of Carbon Nanostructures Using Microsecond Pulsed Arcs". The 6<sup>th</sup> Israeli Conference on Plasma Science and Applications, 12 Feb 2003, Holon.
133. I.I. Beilis, A. Shashurin, D. Arbilly, S. Goldsmith, and R.L. Boxman, "Hot refractory Anode Vacuum Arc Deposition of Copper Films" The 6<sup>th</sup> Israeli Conference on Plasma Science and Applications, 12 Feb 2003, Holon.
134. T. David, S. Goldsmith, R.L. Boxman, "Electro-Optical and Structural Properties of Thin ZnO Films Prepared by Filtered Vacuum Arc Deposition", The 6<sup>th</sup> Israeli Conference on Plasma Science and Applications, 12 Feb 2003, Holon.
135. I. I. Beilis, A. Shashurin, D. Arbilly, S. Goldsmith and R. L. Boxman, "Copper film deposition by a hot refractory anode vacuum arc", Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-2003, San-Diego, USA, 28 April-2 May 2003.
136. T. David, S. Goldsmith, R.L. Boxman, "Electro-Optical and Structural Properties of Thin ZnO Films Prepared by Filtered Vacuum Arc Deposition" Int. Conf. on Metallurgical and Protective Coatings and Thin Films, ICMCTF-2003, San-Diego, USA, 28 April-2 May 2003.
137. R.L. Boxman, V. Zhitomirsky, S. Goldsmith, T. David, V. Dikhtyar, "Deposition of SnO<sub>2</sub> Coatings using a Rectangular Filtered Vacuum Arc Source", Society of Vacuum Coaters Technical Conference, San Francisco, USA, 3-8 May 2003.
138. I.I. Beilis, S. Goldsmith, and R.L. Boxman, "Physical phenomena in a hot refractory anode vacuum arc equation", 49<sup>th</sup> Annual Meeting of the Israel Physical Society, 21 December 2003, (Bull. Is. Phys. Soc. 49, p. 112, 2003) *invited lecture*.
139. R.L. Boxman, N. Parkansky, "Pulsed arc synthesis of nano-materials", Israel Materials Engineering Conference, 24-25 December 2003, Haifa. *Invited lecture*.
140. I. I. Beilis, A. Shashurin, A. Nemirovsky, S. Goldsmith and R.L. Boxman, "Temperature distribution in an asymmetric molybdenum anode of a refractory anode vacuum arc", 7<sup>th</sup> Israeli Conference on Plasma Science and Applications, 1 Feb. 2004, Tel Aviv.
141. I.I. Beilis, A. Shashurin, A. Nemirovsky, S. Goldsmith and R.L. Boxman, Temperature of an asymmetric graphite anode in a refractory anode vacuum arc, 7<sup>th</sup> Israeli Conference on Plasma Science and Applications, 1 Feb. 2004, Tel Aviv.
142. V.N. Zhitomirsky, R.L. Boxman, S. Goldsmith, "Transport of a vacuum arc plasma beam through the aperture of an annular anode", 7<sup>th</sup> Israeli Conference on Plasma Science and Applications, 1 Feb. 2004, Tel Aviv.
143. I.I. Beilis, A. Shashurin, Y. Sivan, S. Goldsmith and R.L. Boxman, "Copper film deposited by a hot refractory anode vacuum arc and a magnetically filtered vacuum arc", 7<sup>th</sup> Israeli Conference on Plasma Science and Applications, 1 Feb. 2004, Tel Aviv.
144. T. David, S. Goldsmith, R.L. Boxman, "p-type Sb-doped ZnO thin films prepared with filtered vacuum arc deposition", 7<sup>th</sup> Israeli Conference on Plasma Science and Applications, 1 Feb. 2004, Tel Aviv.
145. I.I. Beilis, A. Shashurin, A. Nemirovsky, S. Goldsmith and R.L. Boxman, "Anode temperature distribution and coating characteristics in a hot refractory anode vacuum arc with an asymmetric anode", Int. Conf. on Metallurgical Coatings and Thin Films, 19-23 April 2004, San-Diego.

**RAYMOND LEON BOXMAN, Ph.D.**

146. V.N. Zhitomirsky, R.L. Boxman, S Goldsmith, "Influence of the aperture diameter on plasma transport through the annular anode of a vacuum arc plasma deposition system", Int. Conf. on Metallurgical Coatings and Thin Films, 19-23 April 2004, San-Diego.
147. T. David, S. Goldsmith, and R.L. Boxman, "Dependence of ZnO Thin Films Properties on Filtered Vacuum Arc Deposition Parameters" Int. Conf. on Metallurgical Coatings and Thin Films, 19-23 April 2004, San-Diego.
148. T. David, S. Goldsmith, R.L. Boxman, "p-type Sb-doped ZnO films prepared with filtered vacuum arc deposition" Society of Vacuum Coaters Technical Conference, 24-29 April 2004, Dallas.
149. N. Parkansky, R.L. Boxman, I. Zontag, B. Alterkop, Y. Lereah, Z. Barkay, "Pulsed Arc Synthesis of Carbon Nanotubes in Air" Nano 8, 28 June-12 July, Venice, Italy.
150. N. Parkansky, R.L.Boxman, B. Alterkop, S. Goldsmith, Y. Lereah, Z. Barkay, Yu. Rosenberg, G. Frenkel, O. Goldstein, "Pulsed Arc Synthesis of Carbon Nano-particles in Ethanol", Nano 8, 28 June-12 July, Venice, Italy.
151. R.L. Boxman, "A Tutorial on Vacuum Arc Deposition: Physical Principles and Engineering Realization" Workshop on Surface Engineering for Hard Coatings, 4-8 July 2004, Avila, Spain.
152. E. Gidalevich and R.L. Boxman, "Stationary Arc Discharge in a Water Stream", 9<sup>th</sup> Israeli Conference on Plasma Science and Applications", Ein Gedi, 2 March 2006.
153. A. Shashurin, I.I. Beilis, R.L. Boxman and S. Goldsmith "Time Dependent Total Ion Current Measurement in a Vacuum Arc with Refractory Anode", 9<sup>th</sup> Israeli Conference on Plasma Science and Applications", Ein Gedi, 2 March 2006.
154. R.L. Boxman, N. Parakansy, I. Zontag, O. Goldstein, B. Alterkop and G. Frenkel, "Pulsed arc synthesis of carbon nano-tubes and other nano-materials", France-Israel Symposium on Diamond, Carbon Nano-structures and Related Materials, Ein Bokek- Israel. March 6-7, 2006.
155. R.L. Boxman, V.N. Zhitomirsky, Z. Abunie, "Surface Resistivity Distribution of SnO<sub>2</sub> Coatings Deposited Using a Rectangular Filtered Vacuum Arc Deposition System", Society of Vacuum Coaters Technical Conference, 22-27 April 2006, Washington.
156. V.N. Zhitomirsky, E. Çetinörgü, E. Adler, Yu. Rosenberg, R.L. Boxman and S. Goldsmith, "Filtered Vacuum Arc Deposition of Transparent Conducting Al-doped ZnO Films" Int. Conf. on Metallurgical Coatings and Thin Films, 30 April-5 May 2006, San-Diego.
157. Eda Çetinörgü, S. Goldsmith, R.L. Boxman, "Effects of Deposition Conditions on the Characteristics of Highly Transparent and Conducting ZnO-SnO<sub>2</sub> Thin Films Deposited by Filtered Vacuum Arc", Int. Conf. on Metallurgical Coatings and Thin Films, 30 April-5 May 2006, San-Diego.
158. A. Shashurin, I.I. Beilis, Y. Sivan, S. Goldsmith, and R.L. Boxman, "Copper Film Deposition by Hot Refractory Anode and Magnetically Filtered Vacuum Arc Deposition", Int. Conf. on Metallurgical Coatings and Thin Films, 30 April-5 May 2006, San-Diego.
159. S. Goldsmith and R.L. Boxman, "Filtered Vacuum Arc Deposition of Undoped and Doped ZnO Thin Films: Electrical, Optical, and Structural Properties", Int. Conf. on Metallurgical Coatings and Thin Films, 30 April-5 May 2006, San-Diego. *INVITED PAPER.*
160. R.L. Boxman, V. Zhitomirsky, S. Goldsmith, "Vacuum Arc Deposition of Hard and Superhard Coatings", VI-th Int. Conf. on Ion Implantation and other Applications of Ions and Electrons (ION 2006), Kazimierz Dolny, Poland, 26-29 June 2006. *INVITED LECTURE.*
161. I. I. Beilis, A. Shashurin, R. L.Boxman, "Measurement of Ion Flux as a Function of Background Gas Pressure in a Hot Refractory Anode Vacuum Arc", Int. Symposium on Discharges and Electrical Insulation in Vacuum, Matsue, Japan, September, 25-29, 2006.

## RAYMOND LEON BOXMAN, Ph.D.

- 162.D. Gindin, N. Parkansky, R. Boxman, A. Moshkovith, V. Perfiliev, L. Rapoport, Yu. Rosenberg, "Pulsed Air Arc Surface Modification for Friction Reduction", 10<sup>th</sup> Israeli Conference on Plasma Science and Applications, 27 March 2007, Beer Sheva.
- 163.I.I. Beilis, D. Grach, A. Shashurin, and R.L. Boxman, "Copper Metallization of Trenches on a Si Wafer Using a Hot Refractory Anode Vacuum Arc", 10<sup>th</sup> Israeli Conference on Plasma Science and Applications, 27 March 2007, Beer Sheva.
- 164.I.I. Beilis, A. Shnaiderman, A. Shashurin, S. Goldsmith, and R.L. Boxman, "Vacuum Arc with Tungsten Anode: Anode Temperature and Film Deposition", 10<sup>th</sup> Israeli Conference on Plasma Science and Applications, 27 March 2007, Beer Sheva.

## Books

1. R.L. Boxman, P. Martin, D. Sanders (editors), *Handbook of Vacuum Arc Science and Technology*, Noyes Publications (Park Ridge, NJ) 1995.

## Chapters in Books

1. M. Keidar, I. Beilis, R.L. Boxman, and S. Goldsmith, "Free Magnetohydrodynamic Flow of the Low-Density Vacuum-Arc Cathodic Jet", chapter 65 in H. Branover and Y. Unger (eds), *Progress in Fluid Flow Research: Turbulence and Applied MHD*, Vol. 182 in *Progress in Astronautics and Aeronautics*, American Institute of Aeronautics and Astronautics, Reston VI (USA), 1998.
2. V.N. Zhitomirsky, I. Grimberg, M.C. Joseph, E. Gidalevich, R.L. Boxman, A. Matthews, S. Goldsmith and B.Z. Weiss, "Vacuum arc plasma deposition of wear resistant coatings on polymer substrates", in K.L. Mittal (ed), *Polymer Surface Modification: Relevance to Adhesion*, Vol. 2, VSP, Utrecht, 2000.

## Patents

1. R.L. Boxman, "Triggered Vacuum Gap Device with Means for Reducing the Delay Time to Arc-over the Main Gap", U.S. patent 3,581,142, May 25, 1971.
2. R.L. Boxman, S. Goldsmith, S. Shalev, H. Yaloz and N. Brosh, "Method and Apparatus for Surface-Treating Workpieces", U.S. patent 4,645,895, Feb. 24, 1987; Israeli Patent 71530, Dec. 17, 1987. German patent 35 13 014, 24/03/1994. Japanese Patent 1,906,448, Feb. 24, 1995.
3. M. DeLaurentis, K. Pourrezaei, R. Boxman and R. Beard, "Urinary Catheter and System", U.S. Patent 5,295,979, March 22, 1994.
4. N. Parkansky, A. Ben-Shalom, R.L. Boxman, L. Kaplan, S. Goldsmith, H. Yaloz, and M. Nathan, "Method of Producing Transparent and Other Electrically Conductive Materials", U.S. Patent 5,514,229, May 7, 1996.
5. K. Pourrezaei; R.B. Beard; R.L. Boxman; I. Shvets; and M. DeLaurentis, "Method for fabrication of metallized medical devices", U.S. Patent 5,685,961, Nov. 11, 1997.
6. S. Goldschmidt, P. Avivi, H. Rosental, and R. Boxman, "Process and Apparatus for Producing Diamonds", Israeli Patent 105 951, 10 May 1998.
7. N. Parkansky, A. Ben-Shalom, R.L. Boxman, L. Kaplan, S. Goldsmith, H. Yaloz, and M. Nathan, "Method of Producing Transparent and Other Electrically Conductive Materials", U.S. Patent 5,795,631, Aug. 18, 1998.
8. I.I. Beilis, R.L. Boxman, S. Goldsmith, M. Keidar, H. Rosenthal, "Deposition of coatings and thin films using a vacuum arc with a non-consumable hot anode", U.S. Patent 6,391,164, May 21, 2002.
9. R.L. Boxman, S. Goldsmith, Y. David, "Vacuum arc plasma gun deposition system", U.S. Patent 6,706,157, March 16, 2004.

**RAYMOND LEON BOXMAN, Ph.D.**

10. N. Parkansky, L. Rappaport, R.L. Boxman, S. Goldsmith "Method and apparatus for controlling tribological properties using transverse current injection", Israeli Patent 121893, 30 Dec. 2004.

**Thesis**

1. "Triggered Vacuum Interrupters", (S.M. and S.B.), Massachusetts Institute of Technology, Dept. of Electrical Engineering, February 1969.
2. "Interferometric Measurement of Electron and Vapor Densities in a High Current Vacuum Arc", (Ph.D.), Massachusetts Institute of Technology, Dept. of Electrical Engineering, February, 1973.